

ANNUAL REPORT

OF THE

BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING THE

OPERATIONS, EXPENDITURES, AND CONDITION OF THE  
INSTITUTION FOR THE YEAR 1860.

IN THE SENATE OF THE UNITED STATES,

February 26, 1861.

*Resolved*, That five thousand additional copies of the Report of the Board of Regents of the Smithsonian Institution for the year ending the 30th June, 1860, be printed; two thousand for the use of the Smithsonian Institution, and three thousand for the use of the Senate; *Provided*, That the aggregate number of pages contained in said report shall not exceed four hundred and fifty pages, without wood cuts or plates, except those furnished by the Institution.

ASBURY DICKINS, *Secretary*.

L E T T E R  
OF THE  
SECRETARY OF THE SMITHSONIAN INSTITUTION,  
COMMUNICATING

*The Annual Report of the operations, expenditures, and condition of  
the Institution for the year 1860.*

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FEBRUARY 26, 1861.—Read, and ordered to be printed.

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SMITHSONIAN INSTITUTION,  
*Washington, February 25, 1861.*

SIR: In behalf of the Board of Regents, I have the honor to submit to the Senate of the United States the Annual Report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1860.

I have the honor to be, very respectfully, your obedient servant,  
JOSEPH HENRY,  
*Secretary Smithsonian Institution.*

HON. JOHN C. BRECKINRIDGE,  
*President of the Senate.*

ANNUAL REPORT OF THE BOARD OF REGENTS  
OF THE  
SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION UP TO JANUARY 1, 1861, AND THE PROCEEDINGS OF THE BOARD UP TO FEBRUARY 22, 1861.

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*To the Senate and House of Representatives:*

In obedience to the act of Congress of August 10, 1846, establishing the Smithsonian Institution, the undersigned, in behalf of the Regents, submit to Congress, as a report of the operations, expenditures, and condition of the Institution, the following documents:

1. The Annual Report of the Secretary, giving an account of the operations of the Institution during the year 1860.
2. Report of the Executive Committee, giving a general statement of the proceeds and disposition of the Smithsonian fund, and also an account of the expenditures for the year 1860.
3. Proceedings of the Board of Regents up to February 22, 1861.
4. Appendix.

Respectfully submitted.

R. B. TANEY, *Chancellor.*  
JOSEPH HENRY, *Secretary.*

## OFFICERS OF THE SMITHSONIAN INSTITUTION.

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JAMES BUCHANAN, *Ex officio* Presiding Officer of the Institution.  
ROGER B. TANEY, Chancellor of the Institution.

JOSEPH HENRY, Secretary of the Institution.  
SPENCER F. BAIRD, Assistant Secretary.  
W. W. SEATON, Treasurer.  
WILLIAM J. RHEES, Chief Clerk.

JAMES A. PEARCE,  
ALEXANDER D. BACHE, } Executive Committee.  
JOSEPH G. TOTTEN, }

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## REGENTS OF THE INSTITUTION.

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JOHN C. BRECKINRIDGE, Vice President of the United States.  
ROGER B. TANEY, Chief Justice of the United States.  
JAMES G. BERRET, Mayor of the City of Washington.  
JAMES A. PEARCE, member of the Senate of the United States.  
JAMES M. MASON, member of the Senate of the United States.  
STEPHEN A. DOUGLAS, member of the Senate of the United States.  
WILLIAM H. ENGLISH, member of the House of Representatives.  
L. J. GARTRELL, member of the House of Representatives.  
BENJAMIN STANTON, member of the House of Representatives.  
GIDEON HAWLEY, citizen of New York.

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GEORGE E. BADGER, citizen of North Carolina.  
CORNELIUS C. FELTON, citizen of Massachusetts.  
ALEXANDER D. BACHE, citizen of Washington.  
JOSEPH G. TOTTEN, citizen of Washington.

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\* Vacancy caused by the death of Hon. Richard Rush.

## MEMBERS EX OFFICIO OF THE INSTITUTION.

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JAMES BUCHANAN, President of the United States.  
JOHN C. BRECKINRIDGE, Vice President of the United States.  
LEWIS CASS, Secretary of State.  
HOWELL COBB, Secretary of the Treasury.  
JOHN B. FLOYD, Secretary of War.  
ISAAC TOUCEY, Secretary of the Navy.  
JOSEPH HOLT, Postmaster General.  
J. S. BLACK, Attorney General.  
ROGER B. TANEY, Chief Justice of the United States.  
P. F. THOMAS, Commissioner of Patents.  
JAMES G. BERRET, Mayor of the City of Washington.

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## HONORARY MEMBERS.

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BENJAMIN SILLIMAN, of Connecticut.  
A. B. LONGSTREET, of Mississippi.  
JACOB THOMPSON, Secretary of the Interior, (ex officio.)

# PROGRAMME OF ORGANIZATION

OF THE

# SMITHSONIAN INSTITUTION.

[PRESENTED IN THE FIRST ANNUAL REPORT OF THE SECRETARY, AND  
ADOPTED BY THE BOARD OF REGENTS, DECEMBER 13, 1847.]

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## INTRODUCTION.

*General considerations which should serve as a guide in adopting a  
Plan of Organization.*

1. WILL OF SMITHSON. The property is bequeathed to the United States of America, "to found at Washington, under the name of the SMITHSONIAN INSTITUTION, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The government of the United States is merely a trustee to carry out the design of the testator.

3. The Institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally, can be easily reduced to practice, receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate, in some measure, for the loss of time occasioned by the delay of eight years in establishing the Institution,

a considerable portion of the interest which has accrued should be added to the principal.

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should therefore be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of organization, and not the converse.

13. It should be recollected that mankind in general are to be benefited by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

## SECTION I.

### *Plan of Organization of the Institution in accordance with the foregoing deductions from the will of Smithson.*

TO INCREASE KNOWLEDGE. It is proposed—

1. To stimulate men of talent to make original researches, by offering facilities for the preparation of memoirs containing new truths; and
2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.

TO DIFFUSE KNOWLEDGE. It is proposed—

1. To publish a series of periodical reports on the progress of the different branches of knowledge; and
2. To publish occasionally separate treatises on subjects of general interest.

#### DETAILS OF THE PLAN TO INCREASE KNOWLEDGE.

##### I.—*By stimulating researches.*

1. Facilities afforded for the production of original memoirs on all branches of knowledge.
2. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled *Smithsonian Contributions to Knowledge*.
3. No memoir on subjects of physical science to be accepted for publication which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.
4. Each memoir presented to the Institution to be submitted for examination to a commission of persons of reputation for learning in



the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

5. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision be made.

6. The volumes of the memoirs to be exchanged for the transactions of literary and scientific societies, and copies to be given to all the colleges and principal libraries in this country. One part of the remaining copies may be offered for sale; and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

7. An abstract, or popular account, of the contents of these memoirs to be given to the public through the annual report of the Regents to Congress.

II.—*By appropriating a part of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects, so that, in course of time, each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made :

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, mineral, and topographical surveys, to collect materials for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of scientific facts accumulated in the offices of the government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also, explorations and accurate surveys of the mounds and other remains of the ancient people of our country.

DETAILS OF THE PLAN FOR DIFFUSING KNOWLEDGE.

I.—*By the publication of a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. These reports will diffuse a kind of knowledge generally interesting, but which, at present, is inaccessible to the public. Some of the

reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:

#### I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoölogy, geology, &c.
3. Agriculture.
4. Application of science to arts.

#### II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world, penal reform, &c.

#### III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

#### II. *By the publication of separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises should, in all cases, be submitted to a commission of competent judges previous to their publication.

3. As examples of these treatises, expositions may be obtained of the present state of the several branches of knowledge mentioned in the table of reports.

## SECTION II.

*Plan of organization, in accordance with the terms of the resolutions of the Board of Regents providing for the two modes of increasing and diffusing knowledge.*

1. The act of Congress establishing the Institution contemplated the formation of a library and a museum; and the Board of Regents, including these objects in the plan of organization, resolved to divide the income\* into two equal parts.

2. One part to be appropriated to increase and diffuse knowledge by means of publications and researches, agreeably to the scheme before given. The other part to be appropriated to the formation of a library and a collection of objects of nature and of art.

3. These two plans are not incompatible one with another.

4. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

5. The Institution should make special collections, particularly of objects to illustrate and verify its own publications.

6. Also, a collection of instruments of research in all branches of experimental science.

7. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found in the United States.

8. Also, catalogues of memoirs, and of books and other materials, should be collected for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

9. It is believed that the collections in natural history will increase by donation as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase articles of this kind.

10. Attempts should be made to procure for the gallery of art casts of the most celebrated articles of ancient and modern sculpture.

11. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

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\*The amount of the Smithsonian bequest received into the Treasury of the United States is.....\$515,169 00  
Interest on the same to July 1, 1846, (devoted to the erection of the building).. 242,129 00  
Annual income from the bequest..... 30,910 14

12. A small appropriation should annually be made for models of antiquities, such as those of the remains of ancient temples, &c.

13. For the present, or until the building is fully completed, besides the Secretary, no permanent assistant will be required, except one, to act as librarian.

14. The Secretary, by the law of Congress, is alone responsible to the Regents. He shall take charge of the building and property, keep a record of proceedings, discharge the duties of librarian and keeper of the museum, and may, with the consent of the Regents, employ assistants.

15. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art; distinguished individuals should also be invited to give lectures on subjects of general interest.

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This programme, which was at first adopted provisionally, has become the settled policy of the Institution. The only material change is that expressed by the following resolutions adopted January 15, 1855, viz:

*Resolved*, That the 7th resolution, passed by the Board of Regents on the 26th of January, 1847, requiring an equal division of the income between the active operations and the museum and library, when the buildings are completed, be and it is hereby repealed.

*Resolved*, That hereafter the annual appropriations shall be apportioned specifically among the different objects and operations of the Institution in such manner as may, in the judgment of the Regents, be necessary and proper for each, according to its intrinsic importance, and a compliance in good faith with the law.

## REPORT OF THE SECRETARY.

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*To the Board of Regents :*

GENTLEMEN: From the facts presented in the following report of the operations of the Institution, I trust it will be apparent to your honorable Board and the public that nothing has occurred since your last session to interfere with the plan of organization, or with the transactions authorized in accordance with it; on the contrary, I think it will be evident that the labors to increase and diffuse knowledge have been unremitting, and that the results of these labors have met the approval and drawn forth the commendation of intelligent men in every part of the civilized world.

It will also appear that due attention has been paid to the finances, and although the expectation of assistance from the Patent Office on account of meteorology has not been realized, yet the expenditures have been kept within the receipts.

The annual income of the original bequest has been received from the Treasury of the United States, and the interest on the extra fund invested in State stocks has been promptly paid. From the report of the executive committee, it will be seen that there were \$15,034 11 in the hands of the treasurer at the beginning of the year 1860; and that, on the closing of the accounts for receipts and payments for the past year, there is a balance on hand of \$16,521 95. There are, however, outstanding bills, on account of work already contracted for, amounting to about \$4,000, principally for publications which belong to the year 1861.

From this statement, it is apparent that the Institution could wind up its affairs at the present time with all the original fund bequeathed by Smithson in the Treasury of the United States, with an investment of \$140,000 in State stocks, a balance in cash in its treasury of upwards of \$12,000, and an extensive building containing a valuable library and collection of apparatus; and, for the history of its opera-

tions, could refer to twelve volumes of transactions and to other publications which have been printed, and are now to be found in all the principal libraries of the world; to a system of international exchange which has been inaugurated and successfully prosecuted for the last ten years; to an accumulation of a large amount of material in regard to the meteorology and physical geography of the North American continent, and to perhaps the largest collection which has ever been made of the natural history of the same region; and therefore, as far as they are responsible, the administrators could render a satisfactory account of the important trust confided to their care. We hope, however, notwithstanding the threatening aspect of our political affairs, that the time will be far distant when this Institution will be obliged to finally close its accounts. We trust that there is honesty, intelligence, and liberality sufficient in this country, whatever may be its political condition, to sacredly guard the bequest which was intrusted with unhesitating faith to the people of the United States for the good of mankind.

The policy of the Institution, from the beginning, has not been merely to collect and hoard up materials for local purposes, but in every way to promote the cause of science generally, by a liberal but prudent expenditure of its income in advancing among men the various branches of knowledge to which its efforts have been directed. For example, a great amount of labor has been expended in collecting specimens of natural history; and it will be seen, by the remarks on the collections that active measures are now in progress for rendering the results widely available for the purposes of science and education, by a general distribution of the duplicates.

The several objects to which the expenditures and labors of the Institution have been devoted during the last year, are nearly the same as those mentioned in previous reports; and in describing them we shall follow the order heretofore adopted.

*Publications.*—The twelfth volume of the *Smithsonian Contribution to Knowledge* has been completed, and will be ready for distribution as soon as it comes from the hands of the binder. It consists of 537 quarto pages, and is illustrated by three plates and twelve wood cuts. The following is a list of its contents:

I. Astronomical observations in the Arctic seas, by Elisha Kent Kane, M. D.

II. On fluctuations of level in the North American lakes, by Charles Whittlesey.

III. Meteorological observations made at Providence, Rhode Island, for 28½ years, by Prof. Alexis Caswell.

IV. Meteorological observations made near Washington, Arkansas, for 20 years, by Dr. Nathan D. Smith.

V. Researches upon the venom of the rattlesnake, with an investigation of the anatomy and physiology of the organs concerned, by Dr. S. W. Mitchell.

1. The first of the papers mentioned above forms the third part of the series of memoirs on the results of the observations of Dr. Kane, during the second Grinnell expedition. An account of the first and second numbers of the series, relating to magnetism and meteorology, has been given in the two preceding reports. The third, or present paper, gives the discussions and results of the astronomical observations which were made, principally at Van Rensselaer harbor, the winter quarters of the expedition during 1853-54-55. These observations were under the especial care of Mr. August Sonntag. The principal instruments employed were two sextants by Gambey, divided to ten seconds, a theodolite, a transit instrument, and five mean time chronometers. The observatory consisted of four walls of granite blocks cemented together with moss and frozen water. The transit and theodolite were mounted on piers formed of an extemporaneous conglomerate of gravel and ice, well rammed down into iron-hooped casks, and afterwards consolidated by water. Thus constructed, they were found to be as firm as the rocks on which they rested.

The first observations for latitude were made with the theodolite, and later ones by means of a sextant and artificial horizon, on the moon and moon-culminating stars. The time was noted by a pocket chronometer. The instrument was properly adjusted in position, but in consequence of the high latitude and the extreme cold, this was a very difficult operation. The angle of elevation was, in many cases, observed by the reflection of the image of the object from a mercurial horizon; the bubble of the level having been rendered useless by the extreme reduction of temperature to which it was subjected.

Observations were also made on occultations and eclipses, namely: the occultation of Saturn, December 12, 1853; of the same planet, January 8, 1854, and February 4, 1854; of Mars, February 13, 1854; and on the solar eclipse of May 15, 1855. In the occultations of Saturn, the disappearance and reappearance of the more prominent points of the ring were accurately noted, and the results have been elaborately discussed by Mr. Schott. From all the observations, the

longitude finally adopted for the observatory of Van Rensselaer harbor was  $70^{\circ} 52' 45''$  west from Greenwich. It may be interesting to remark that the degree of longitude in this high latitude is a little less than twelve nautical miles, (11.88.)

Besides the astronomical observations at Van Rensselaer Harbor, a number were made on the coast of Greenland when the expedition was on its way to its winter quarters, and a series for determining latitudes by travelling parties at different points in the regions explored.

From the full discussion of the whole series of observations both for latitudes and longitudes a new map which accompanies the paper has been protracted. This map differs from that given in Dr. Kane's narrative in shifting the position of the shore line of Kennedy Channel to the southward about nineteen nautical miles. The highest point of the eastern shore line traced on the corrected map is in latitude  $80^{\circ} 56'$ , and that on the western side of the channel  $82^{\circ} 7'$ . These are the northern limits of the exploration of the Grinnell expedition.

The fourth and last series of discussions and results of observations made by Dr. Kane during the second expedition has also been printed, and will form a part of the thirteenth volume of the Smithsonian Contributions. It relates to the tides in the Arctic seas. Occasional observations on the height of water were taken after passing Smith's straits, but the principal number recorded were made at Van Rensselaer Harbor. The series at this place commenced in September, 1853, and was continued to January, 1855. The observations during this period are very unequal in value, owing mainly to physical difficulties. The observations, by means of a sounding line or staff, were subject to irregularities from a slow movement of the vessel, which, though imbedded in the ice a greater part of the year, was not entirely stationary. The observations, by means of a string passing over a pulley and attached to a float, were also subject to certain irregularities due to an occasional slipping of the rope over the pulley, and another small variation caused by the gradual rising of the deck of the vessel above the level of the water, in consequence of her becoming lighter by the daily consumption of provisions and fuel.

In discussing these observations it was necessary in the first place to reduce the measurements to the same zero or level of the sea. To effect this, two curve lines were traced on paper, the upper one including the maximum rise of water for each day, and the other the lowest water for the same time. An intermediate line traced equidistant from these curves was then assumed to represent the mean elevation, and this straightened out was adopted as the axis of the mean level of the sea.



The corrections for referring each observation to the standard level were taken from this diagram—no allowance being considered necessary for a change in the variation of the mean level of the sea. All the observations properly corrected are given in a series of tables. From these tables, another series was deduced, exhibiting in one view the apparent time of high and low water, and the corresponding passages of the moon over the meridian, its declination and comparative distance from the earth. These latter tables were again plotted, and from the curves thus produced it appears that the average time of the occurrence of a series of 480 high waters at Van Rensselaer harbor was eleven hours and forty-three minutes after the passage of the moon across the meridian, corresponding to a mean declination of the sun and moon of sixteen degrees.

In like manner from 485 observations, the average time of low water occurred seventeen hours and forty-eight minutes after the passage of the moon over the meridian. The average interval of time between the high and low water was six hours and five minutes.

The tide wave at Van Rensselaer Harbor may be considered as transmitted from the Atlantic ocean, and only in part modified by the small tide originated in the waters of Baffin's Bay. This latter tide must necessarily be small, since the direction of the long and comparatively narrow bay is at right angles to that which would be most favorable to the production of a disturbance of this kind. That the ocean tide wave actually travels up along the coast of Greenland, or, in other words, that it reaches Van Rensselaer Harbor from the south, is proved by comparing the time of high water at different places along the west coast of Greenland.

Having the velocity of the tide wave along Baffin's Bay and Smith's Straits, the depth of the water may be approximately obtained. Assuming the distance along the channel, between Holsteinborg and Van Rensselaer Harbor, to be 770 nautical miles, the tidal wave has a velocity of 202 feet in a second, which, according to Airy's table, would correspond to a depth of about 1,300 feet. In the same manner, by comparing the co-tidal hours at Upernavik with those of Van Rensselaer Harbor, a resultant depth of nearly 4,800 feet is obtained. These two may be considered as the limits of the depths in Baffin's Bay and Smith's Straits.

Besides the points noticed, several others are fully discussed in this paper. Among these is what is called the diurnal inequality, or the difference between the height of the two tides at the same phases of the moon, depending principally on her position with reference to the

equator, as well as on her passage across the superior and inferior meridian of the place. The moon produces high water at the same instant of time on opposite sides of the earth, and were she constantly to move in the plane of the equator, the highest points of these tides would also be in the plane of the equator, and would consequently produce a series of equal tides at any place either north or south of this line. But it is evident that, when she ascends to the north, the plane of the highest tide will tip in the same direction, giving the highest point of one tide in the northern and the highest point of the other tide in the southern hemisphere. Consequently, when the moon has a northern declination, the tide at any place in the northern hemisphere which follows immediately after her passage across the meridian will be higher than one which passes twelve hours later. This variation in the height of the two tides is called the diurnal inequality. From theoretical considerations it would not be anticipated that this inequality should be well marked in such high northern regions; but since the movement of the water at Van Rensselaer's Harbor is not due directly to the action of the sun and moon, but is the effect of an immense wave propagated from the Atlantic through Baffin's Bay and Smith's Straits, this inequality becomes well marked.

About the time of the moon's maximum declination, the difference between the day and night tide was two and a half feet. By an examination of the diagrams on which the elevations of the tides are exhibited, it is seen that sometimes the day and sometimes the night tides are the highest; and, furthermore, that the difference vanishes a day or two after the moon crosses the equator, and that it reaches its maximum a few days after the moon attains its greatest declination north or south.

The form of the tide wave is also investigated and expressed in a diagram, from which it appears that the spring tide wave is slightly steeper between low and high water than between high and low water, or, in other words, that the water rises more rapidly than it falls, and also that the neap-tide wave is nearly symmetrical, the rise and fall taking place in nearly equal times.

The tabulated observations were also investigated in reference to the varying position of the sun and moon, giving rise to what is called the half monthly inequality, and the result of this is also plainly indicated by diagrams, for the high water as well as for the low. This paper, as we have stated, completes the results of the discussions of the series of observations made under the direction of Dr. Kane, and, by themselves, or in connection with other researches in the Arctic

regions, are valuable additions to our knowledge of the physical geography of the earth.

I regret to be obliged to state that since the publication of the paper on the winds at Van Rensselaer Harbor, some doubt has arisen as to the proper interpretation of the original record. It is stated by Dr. Kane that the observations of wind were uncorrected for magnetic variation. In consequence of this statement a correction was applied by Mr. A. Schott to reduce them to the true meridian. Mr. Sonntag, one of the principal observers, after his return from Mexico, asserted that the observations of the wind were recorded in reference to the true meridian, and therefore required no correction. The same statement was subsequently made independently by Dr. Hayes. An appendix has therefore been prepared for the series giving the corrections to be applied to the tables, in order that the results may be in conformity with either assumption. The weight of testimony would appear to be in favor of the supposition that the records of the wind at Van Rensselaer Harbor were recorded with reference to the true north; but the question cannot be fully settled until other observations from the same place are obtained.

The next paper in the 12th volume of Contributions is on the fluctuations of the level of the surface of the North American lakes. It has long been known that the great interior fresh water seas of North America are subject to variations of level. From the observations given in this paper and others previously published, the fluctuations are of three kinds: First. A general rise and fall, extending through a period of many years, which may be called the secular variation of level. It evidently depends on peculiar changes in the meteorology of the country drained, and although it may probably have a regular period of return, this has not yet been determined. Second. An annual rise and fall, the period of which is completed in about twelve months, which is caused by the changes of the seasons, can be predicted with considerable certainty, and is properly called the annual variation. Third. An irregular movement, producing frequently a sudden elevation, from a few inches to several feet. This is of two kinds, one evidently due to the wind, and the other resulting from rapid undulations in calm water. Both classes may be styled transient fluctuations. To these a fourth may be added, according to a late publication by Colonel Graham, United States Army, which is a true lunar tide. The author of this paper professes to have condensed from all sources within his reach information respecting the fluctuations of the water since the settlement of the country,

The whole is arranged in tables giving the dates of observation and the authorities from which they have been obtained. Although these tables are doubtless very incomplete, they have been accepted for publication as contributions to the subject, to be corrected and enlarged by subsequent observations.

A series of observations accurately made with properly arranged tidal instruments, such as are employed on the coast survey, and continued for a number of years, would be of much interest to science, as well as of value to commerce in the construction of wharves and the selection of harbors. Such a series has been established under the direction of Captain Meade, United States Topographical Engineers, which, with the observations under the direction of Colonel Graham, at Chicago, will furnish, if continued, the data required. We think it not improbable that, if the series is sufficiently extended, a law of periodicity will be discovered in the recurrence of the long intervals of rise and decline, and that these will have some relation to a periodical variation of the seasons in a series of years.

The most remarkable phenomena in regard to the fluctuations of the lakes are those of the fitful oscillations in which sometimes a sudden rise occurs of several feet at a particular place in calm weather, and also a series of minor agitations. The simplest hypothesis for the explanation of these phenomena is, that they are produced by the passage of atmospheric waves, such as are caused by thunder-storms, and perhaps in some cases by water-spouts, across distant parts of the lake. It is well established by observation at the Smithsonian Institution, as well as at other places, that rapid oscillations of the barometer accompany the passage of thunder-storms across the meridian. The mercury suddenly descends, then rises a little, and again falls, and after this regains its former level as the storm passes off to the east. A thunder-storm, therefore, in crossing the lake, would cause an elevation of water directly under it, which, in subsiding, would give rise to undulations, and these arriving in succession from every point of the path of the storm would produce effects similar to those which have been noted.

Since the whole lunar tide of the ocean does not exceed five or six feet, the effect of the moon even on such large bodies of water as those of the upper lakes must be very small. Colonel Graham finds the difference between high and low water at spring tides, at Chicago, on Lake Michigan, to be about three inches and a half, and to occur at thirty minutes after the passage of the moon over the meridian. It is probable that the height of the tide on Lake Superior would be greater

than this, and might best be observed at the narrowing portion of the extreme western end of the lake.

The twelfth volume of Contributions will also contain the records of meteorological observations made at Providence, by Prof. Caswell, an account of which was given in the last report. This series of observations occupies 179 of the largest quarto pages which can be introduced into the volumes of the Smithsonian Contributions. They comprise a record of the barometer and thermometer made three times a day, the direction and force of the wind, and the face of the sky for the same period; also, the depth of rain, together with a column of general remarks on casual phenomena. The series is terminated by a number of general tables—the first giving the monthly and annual mean height of the barometer during the whole term of years; the second, the monthly and annual mean height of barometer at sunrise or 6 a. m., 1 or 2 p. m., and 10 p. m.; third, monthly and annual mean temperatures, deduced from the three observations daily; fourth, monthly and annual mean temperatures at sunrise or 6 a. m., 1 or 2 p. m., and 10 p. m.; fifth, monthly and annual maximum and minimum temperatures and range; sixth, the number of days in each month in which the prevailing winds came from each of the four quarters of the horizon; seventh, mean force of the wind at the different hours of observation, and for the month and year; eighth, mean cloudiness of the sky at the different hours of observation, and the mean for the month and the year; ninth, monthly and annual number of days in which the weather was clear, variable, or cloudy—on which rain or snow fell; the tenth, monthly and annual quantity of rain and snow in inches.

From the records themselves an account of the weather on any day for twenty-eight years past may be obtained. From the general tables we can determine the connection of the variations of the barometer with the changes of the weather, and deduce rules of practical importance as well as of scientific interest. From the tables of the records of the thermometer, we find that the mean temperature of Providence for the whole time is  $48^{\circ} 19'$ , and that during the twenty-eight years of observation the oscillation on either side of this, with the exception of four years, is within a single degree.

The coldest year was that of 1836; the warmest was 1848. The warmest January was that of 1843, and the coldest that of 1857, which was also the coldest single month of the whole period. On an average, the coldest month of the year is February; the warmest month is July; and the warmest month of any summer of the whole period was August,

1848; and the next warmest, July, 1838. The mean annual amount of rain is 40.38 inches, distributed with considerable regularity. The month in which the most rain falls, on an average, is August; and that in which the least falls is February.

Another paper in the twelfth volume of Contributions is a series of meteorological observations, similar to the preceding, made at Washington, Arkansas, by Dr. Nathan D. Smith.

The place at which these observations were made is on the summit of the dividing ridge between the waters of the Red river and those of the Washita, fifteen miles northeast of Fulton and twenty south of the Little Missouri. From this ridge there is no higher level for a long distance; but to the northwest there is a gradual ascent for about fifty miles, to the foot of the mountains.

The records are of observations of the temperature at sunrise throughout the year, and at 2 p. m. in the winter, and 3 p. m. in the summer; amount of rain, and remarks on the weather; with the daily mean temperature, and monthly mean, maximum, minimum, and range, from January 1, 1840, to December 31, 1859, a period of twenty years. Appended to these observations are tables giving the following summaries for each month and year and for the whole series of twenty years:

1. Extremes of temperature. The highest temperature at sunrise and at 2 or 3 p. m.; the mean temperature of the warmest day; the lowest temperature at sunrise and at 2 or 3 p. m.; and the mean temperature of the coldest day.
2. Variations of temperature. Range of temperature at sunrise and at 2 or 3 p. m., and of the daily mean temperature; the extreme range of temperature; the greatest rise and fall of temperature from sunrise of one day to sunrise of the next day; the greatest rise and fall from 2 or 3 p. m. of one day to 2 or 3 p. m. of the next day.
3. Mean temperatures. Means at sunrise and at 2 or 3 p. m.; of months, years, and seasons; and of each day, as deduced from the observations for the whole twenty years.
4. The amount of rain for each month and year, and monthly and annual means for the whole series.

These tables, as in the case of those for Providence, furnish a series of interesting facts. For example: the mean temperature of the whole period is  $61.81^{\circ}$ ; the warmest month is July, the coldest January; the warmest year was 1854, the coldest year was 1843. The coldest New Year's day recorded was that of 1840, the mean temperature of which was  $22^{\circ}$ ; the warmest 1846 and 1855, the mean temperature of each being  $57^{\circ}$ . From these tables it appears that the coldest day in the

year, as deduced from the average of twenty years, is the 18th of January, and the warmest the 15th of July.

The mean annual amount of rain is 54.70 inches; the month of the greatest rain is April; of the least rain, September.

The last paper in the twelfth volume of Contributions consists of an account of researches upon the venom of the rattlesnake, with the investigations of the anatomy and physiology of the organs concerned, by S. Weir Mitchell, M. D.

This paper gives an account of a series of investigations relative to a subject which, from an almost instinctive aversion to venomous snakes and the danger to which the student is exposed, has received comparatively little attention. With the exception of the essays of Barton and Brainard, the literature of this subject in this country has been confined to scattered notices and incomplete statements of cases found in the pages of numerous medical journals, and, indeed, if we except a few works of Europe and India, in no part of the world has modern science done much to further this inquiry.

The author first gives an account of his observations on the habits of the rattlesnake when in captivity. From ten to thirty-five snakes were kept together in the same box without exhibiting the slightest signs of hostility to one another. Even when snakes were suddenly dropped upon their fellows no attempt was made to annoy the new comers, while the intrusion of a pigeon or a rabbit immediately roused the reptiles when they were in vigorous health. The habits of this snake in confinement are singularly inactive. In warm weather, when least sluggish, they lie together in a knotted mass, occasionally changing their position, and then relapsing into a state of perfect rest. This sluggish condition is dangerously deceptive, since it gives no indication of the rapidity of their motion when aroused. This reptile seldom eats in captivity. The author has kept one alive for a year without food, and though he made every effort to tempt the snakes to eat, he has never seen them disposed to avail themselves of food when placed within their reach. Some of them were forcibly fed by placing milk and insects in their throats, yet when even this precaution was not taken, provided the snakes had water, they continued healthful, and secreted a large amount of venom.

The author's observations add nothing towards confirming the idea of the disputed power of fascination in the snake. Birds, guinea-pigs, mice, and dogs, put into the cage generally exhibited no terror after the alarm had subsided occasioned by having been dropped into the box. The small birds soon became singularly familiar with the snakes,

and were seldom molested even if caged with six or eight large ones. Mice also lived on terms of confiding intimacy, sitting on the heads of the snakes and running over their coils, apparently unconscious of danger. Larger animals were not so safe in this, especially if they moved rapidly. All the animals frequently manifested an evident curiosity which prompted them to approach the snake, but this was sometimes reprov'd by a blow, particularly when a dog indulg'd his inquisitiveness by approaching his nose too close in the act of smelling. In a state of rest no odor is observed from the snake; but when it is roughly disturbed and induced to throw itself into contortions, a thin stream of yellow or dark brown fluid is ejected, the odor of which is extremely disagreeable.

The author next describes, from his own dissections, the anatomy of the parts connected with the secretion and expulsion of the venom. He also gives a full and complete account of the part played by the various muscles in the act of inflicting a wound. When preparing to strike, the snake throws his body into a coil, and by a violent contraction of the muscles which lie on the convexity of the bends, a portion of the body is immediately straightened and the head thrown forward in a direct line to a distance not exceeding one half of its length. The hooked fangs are made to enter the flesh of the victim and retained there until the venom is injected by a series of muscular contractions minutely detailed in the description. From this it appears that the animal may sometimes fail to inflict injury when seeming to do so. A knowledge of these facts is essential to a proper study of antidotes for the bite of the rattlesnake.

The venom is yellow, acid, glutinous, and of a specific gravity of 104. It is devoid of taste, smell, and acidity; begins to coagulate at 140° Fah., and is soluble in water. It consists, first, of an albuminoid substance, which is coagulable by pure alcohol, but not by a heat of 212° Fah. This material is the poisonous element, and receives from the author the name of crotaline; second, of an albuminoid compound, coagulable both by heat and by alcohol, and not poisonous; third, a yellow coloring matter and an undetermined substance, both soluble in alcohol; fourth, a trace of fatty matter and of free acid; fifth, saline bodies, chlorine, and phosphates.

The venom gland presents some anatomical analogy to that in which the saliva of other animals is formed; but there is an entire want of physiological resemblance between the venom and the saliva. It was found that no temperature from zero to 212° Fah. destroyed the poisonous property of the venom, which also remained unaltered when it



was treated with acids and alkalis at moderate temperatures, or with alcohol, chlorine water, iodine, &c. It prevented the germination of seeds planted in it, but did not destroy the vitality of large plants inoculated with it, nor did it interfere with saccharine fermentation nor with the accompanying growth of sporules.

The effect of the venom on cold blooded animals was studied on frogs and on the rattlesnake itself. In both the symptoms were like those in warm blooded animals, but very much slower of development. In the latter the effects were examined on pigeons, reed-birds, rabbits, guinea-pigs, and dogs, in all of which careful examination of the post-mortem lesions were made. The influence of the venom on the tissues and fluids of the economy is given in detail, and the following are some of the conclusions arrived at:

In all animals which die within a very short period after being bitten, there is no other lesion than the wound, the blood and tissues both being normal in appearance. In animals whose lives are prolonged, the blood is diseased and the tissues more or less altered. The venom is not absorbed by the stomach or the skin, but when drawn into the lungs of a pigeon it is fatal. The bite is attended with no primary inflammation, and the local swelling is due to effusion of fluid or semi-fluid blood. The muscles wounded by the fang are affected with twitching at first, and afterwards undergo a peculiar softening, and become more liable to rapid putrefaction than other parts. The muscular irritability ceases earlier than in ordinary cases of death, while the rigidity occurs as usual. The intestinal motions and those of the cilia are unaltered. The heart becomes enfeebled shortly after the bite, from direct influence of the venom on this organ, and not from the loss of the respiratory functions. Notwithstanding the diminution of its power, the heart is usually in motion after the lungs cease to act, and its tissues remain for a long time locally irritable. The paralysis of the heart is therefore not so complete as it is under the influence of upas or corroval. In warm-blooded animals artificial respiration prolongs the contractile power of the heart, but does not sustain it as long as when the animal has died by woorara or decapitation. In the frog, the actions of the heart continue after respiration has ceased, and sometimes survive until the sensory nerves and the nerve centres are dead, the motor nerves alone remaining irritable. In warm-blooded animals, respiration ceases, owing to paralysis of the nerve centres. The sensory nerves, and the centres of nerve power in the medulla spinalis and medulla oblongata, lose their vitality before the motor nerves become affected.

In cold-blooded animals the muscular system retains its irritability for a considerable time after death, so that this cannot be due to its loss. The first effect of the venom being to depress the vital energy of the heart and nerve centres, a resort to stimulants is clearly indicated as the only rational mode, in our present state of knowledge, of early constitutional treatment. In chronic poisoning, death is due to the continued influence of venom on the heart and nerve centres, and to secondary alterations of the blood and tissues. In these cases the fibrin of the blood is more or less dissolved, and the corpuscles are rarely and slightly altered, and not at all in animals which die soon after being bitten. The venom produces changes analogous to those in cases of yellow fever and some other maladies.

These conclusions rest on a series of apparently well-devised and carefully-executed experiments. They are principally original results, and the whole paper must, therefore, be considered a valuable addition to our knowledge of this interesting subject.

Attached to the memoir is an appendix containing an enumeration of the genera and species of rattlesnakes, with synonymy and references by E. D. Cope; also, a full bibliography of the subject by the author, with critical and analytical notices of the works mentioned; and this, with the authorities given by Mr. Cope, furnishes a complete list of all writers either on the natural history, or on the anatomy, physiology, and toxicology of venomous serpents in general. The paper is illustrated with wood cuts, and the author acknowledges his indebtedness to this Institution for aid in procuring the serpents which were essential to his investigations.

Professor. Bache has presented for publication the second of his series of discussions of the magnetic observations made at Girard College between the years 1840 and 1845. Part 1 of this series, which is described in the last report, related to the investigation of the eleven-year period, or that which is coincident with the recurrence of frequency of the spots on the sun, and to other variations of the needle connected with solar action. The present paper relates to the influence of the moon on the variation of the magnetic needle.

The existence of a sensible lunar effect on the magnetism of the earth has been established by the labors of Sabine and others; it is, however, of much importance to confirm and extend their results by the discussion of independent observations. In the previous paper the method was shown by which the several influences of the sun were eliminated from the observations, leaving residuals from which the lunar influence could be deduced, the method being that followed by

General Sabine in his reduction of the results of the British observations. The records, after having been corrected for the influence of the sun and other perturbations, were arranged in tables, corresponding to the several hours of the day, commencing with the upper transit of the moon over the meridian. To ascertain whether the different parts of these series would give harmonious results, the whole number tabulated, 21,644, was divided into three groups, the first comprising nineteen months, the second, twenty-one months, and the third, eighteen months. From these it was found that the results were nearly proportioned to the number of observations, which indicated that no constant error of much magnitude existed.

The three groups were next discussed by means of Bessel's formula, two terms of which were found sufficient to give a curve representing the observations; and as a constant term was not found necessary in the construction of this curve, it was inferred that the moon exerted no specific constant action on the needle, or, in other words, that the magnetism of the moon is not *per se*, but is of that kind called *inductive*, which is due to the action of some extraneous body.

The curves by which the results of the discussion are represented show two east and two west deflections in a lunar day, the maxima east and west occurring about the time of the upper and lower transit of the moon over the meridian, and the minima about at the intermediate sixth hour.

In comparison with the effects of other forces operating on the magnetic needle, that of the moon is exceedingly small, and could not have been detected previous to the introduction of the more refined instruments and methods of investigation which have been invented within the last twenty years. The total range at Philadelphia scarcely reaches thirty seconds, and at Toronto it is only a little more than thirty-eight seconds.

The principal western maximum deviation occurs six minutes after the moon passes the lower meridian, and amounts to 13.8 seconds of arc. The secondary maximum occurs fourteen minutes after the upper culmination, and amounts to 10.8 seconds. The principal eastern maximum of variation takes place six hours and seventeen minutes after the lower culmination, the deflection being 13.2 seconds. The secondary easterly maximum occurs at six hours three minutes after the upper transit, and amounts to 11.4 seconds.

The effect of the moon appears to be subject to a variation depending on the solar year, for the investigation of which the preceding results were arranged in two groups—one containing the hourly values for

the summer months, and the others those for the winter months. After being subjected to a similar process of reduction, it was found from these that the lunar variation is much smaller in amplitude in winter than in summer, and also that the maxima and minima occur earlier in the former than in the latter season, the winter curve preceding the summer curve by about an hour and three quarters.

Professor Bache next proceeded to ascertain whether the phases, declination, or parallax of the moon have any sensible effect on the magnetic variation. Dr. Kreil, from the discussion of ten years' observation at Prague, concluded that there was no specific change in the position of the magnet depending on the moon's phases or parallax, but that the variation was sensibly greater when the moon was at its greatest northern declination. On the contrary, Mr. Brown, from a much shorter series of observations in India, inferred that there was a minimum of variation two days after the full moon. To investigate these points, the lunar variation for the days of full and new moon, and for two succeeding days, were compared with the average monthly variation; the results indicate that the north end of the magnet is deflected six seconds to the westward at full moon, and as much to the eastward on the day of new moon. This quantity is not much beyond the probable error of observation, but a more definite result could hardly be expected from a series extending over but five years. The period of the observations is also too short to exhibit any definite variation depending on the moon's greatest northern or southern declination, and the same remark may be applied to the effect of the varying distance of the moon. Professor Bache proposes, in another paper, to extend the discussion to the moon's influence on the variation in the intensity of the magnetic force of the earth.

I neglected to mention in the last report that, besides the magnetic observations made by Professor Bache in coöperation with the system inaugurated by the British association, two other series were carried on simultaneously—one in the city of Washington, by Lieutenant Gilliss, of the United States Navy, and the other by Professor Bond, of Harvard University. The observations of Lieutenant Gilliss were made once in two hours with a bar eleven inches long, observed with a micrometer microscope reading to seconds of arc, and were continued from July 7, 1840, to June 30, 1842, a period of two years. Beside the bi-hourly series, another was made on term days, viz: on the 23d and 24th of each month, from September, 1840, to June, 1842, in which the position of the needle was recorded at intervals of every five minutes. Professor Bond's observations at Cambridge extended

from 1837 to 1845. The observations of Lieutenant Gilliss were published by order of the Senate of the United States; but have not been discussed in reference to the various influences to which the needle is subjected. Those of Professor Bond are still in manuscript, but will probably be published in due time, as a part of the labors of the Harvard observatory.

The fact was mentioned in the last report, that a small appropriation had been made, to assist in defraying the expense of the necessary material and apparatus for an investigation undertaken by Professor Wolcott Gibbs relative to the ores of platinum, of which the following is an account:

Samples of the ores of platinum, according to Gmelin, were first brought to Europe in the year 1741. In 1748, the metal was described by Don Antonio de Ulloa as a metallic stone, which, when present in large quantity, prevents the working of the gold ores. Watson recognized platinum as a distinct metal in 1750, and after that period very numerous investigations were published in regard to it. In 1804, Wollaston announced the discovery of palladium and rhodium in the raw platinum ores, and shortly afterward Smithson Tennant showed that the same ore contained two other metals, which he called iridium and osmium. Finally, in 1844, Claus discovered ruthenium. The investigation of the metals accompanying platinum has always been regarded as one of peculiar difficulty, in consequence of the remarkable analogies between the chemical properties of the metals themselves. The comparatively recent discovery of ruthenium illustrates this point in a striking manner. All previous investigations related chiefly to mixtures of the metals in various proportions, hardly a single one having been obtained in a state of purity. Claus's most elaborate and successful investigation threw a new light on the whole subject, without, however, removing all the difficulties which accompany a complete separation of the different metals. In 1859, Deville and Debray published a detailed memoir on the working of the ores of platinum upon a large scale, and on the physical properties of the different metals. In this very valuable paper, methods of fusing large quantities of platinum are given, the processes employed being, however, essentially the same as those successfully used in this country by Dr. Hare many years since.

The purely chemical question of the complete separation of the different metals of the platinum group from each other, remained unsolved. The investigations of Dr. Gibbs have been undertaken partly to supply this deficiency, and partly in consequence of his dis-

covery of a very remarkable series of compounds containing osmium, ruthenium, or iridium. These investigations have thus far been successful, a few difficulties only remaining to be overcome. They have not merely yielded wholly new methods of separation, but have resulted in the discovery of an entirely new class of salts, possessing much theoretical and practical interest. It is by means of these salts that Dr. Gibbs has succeeded in effecting a satisfactory separation of the different metals of the group. The memoir embodying a detailed description of the processes of Dr. Gibbs will consist of four parts. The first will treat of the methods of bringing the ores into a soluble condition; the second, of the methods of separating the metals from each other; the third, of the new salts and bases discovered; and the fourth, of the general relations of the metals of the group. A large part of the work is already completed, and the author expects to have the whole ready for the press in a few months.

Beside the papers described, a number of others have been accepted for publication, or are in preparation, at the expense of the Smithsonian fund. Among the former we may mention an elaborate memoir on the anatomy of the human liver, by Dr. Schmidt, of New Orleans, of which the following are the principal points: 1. The accumulation of additional evidence of the existence of a network of capillary vessels previously discovered by the author, and described by him as "biliary tubules," from which start the smallest hepatic ducts. This network is independent of that in which the smallest branches of the portal vein, hepatic artery, and veins arise. 2. The discovery of minute lymphatics of the liver, and their origin in the network of biliary tubules, by which a communication between the hepatic ducts and lymphatics is established. 3. The discovery of lymphatic vessels, *directly* joining small hepatic ducts, by which a *second* communication between these vessels is established. 4. A minute description of a system of small follicular and racemose glands, the ducts of which form extensive plexuses throughout the liver, and their relationship to the other constituents of the organ. These glands have been imperfectly described by some authors, but their true relations have never been known. 5. The discovery of a communication of the lymphatics with the ducts of these glands. As many of the latter join the hepatic ducts, a *third* communication between the lymphatics and hepatic ducts is thus *indirectly* established.

The memoir also contains several other points of minor importance, together with a minute description of the blood vessels, hepatic cells, &c., perhaps more definite than has heretofore been given. The dis-

covery of a natural communication between the hepatic ducts and lymphatics of the liver, according to the author, is of great importance, for it explains the phenomena of jaundice as they occur in certain diseases. It also explains why the large lymphatics on the surface of the liver are frequently found filled with bile after death. The appendix to the memoir contains a description of the best method of making minute injections, together with the apparatus used for the purpose.

In addition to the foregoing, an original mathematical paper on the intersection of circles and spheres, has been presented by Major Alvord, of the United States Army.

Among the memoirs in preparation is one on Arctic meteorology, from the original observations made under the direction of Sir F. Leopold McClintock, during his late voyage in search of Sir John Franklin, and presented to this Institution by the author, for discussion and publication. A full account of this paper and the preceding will be given in the next annual report.

Under the head of *Smithsonian Miscellaneous Collections*, the following works have been published during the past year:

1. Instructions in reference to collecting nests and eggs of North American birds; illustrated with wood cuts.
2. Circular in reference to the history of North American grasshoppers; prepared by Mr. P. R. Uhler.
3. Circular in reference to collecting North American shells.
4. Circular addressed to the officers of the Hudson's Bay Company, relative to the registration of meteorological phenomena, and the collection of objects of natural history. This circular is accompanied by a letter from the late Sir George Simpson, governor of the Hudson's Bay Company's territory, commending the requests of the Institution to the favorable consideration of all persons connected with the company.
5. Check lists of the shells of North America, prepared for the Institution by Isaac Lea, P. P. Carpenter, W. Stimpson, W. G. Binney, and T. Prime. These lists were prepared for the purpose of labeling the specimens in the Smithsonian collection, but as it was thought they would be of general value in the indication of species inhabiting this continent and the adjacent islands, in facilitating the preparation of catalogues, the labeling of collections, and conducting exchanges, it has been thought proper to print them for distribution.
6. List of duplicate shells of the Indo-Pacific Fauna, collected by the United States exploring expedition under Captain Wilkes.

7. Catalogue of the described lepidoptera of North America, by Dr. John G. Morris. This catalogue enumerates over 2,000 species of butterflies, moths, &c., which occur in the United States proper. "Yet there is reason to believe," says the author, "that hundreds still remain to be discovered." In the preparation of this catalogue, all accessible books have been consulted, and it is believed that few descriptions of American lepidoptera have been overlooked. The classification adopted is that recommended in part by Herrich-Schaeffer and Walker; but in some of the families, Guénée has been followed.

The following works are in preparation for publication in the Smithsonian miscellaneous collections:

\* 1. Elementary introduction to the study of conchology, by P. P. Carpenter, of Warrington, England.

2. List of the species of shells collected by the United States exploring expedition, by the same author.

3. Descriptive catalogue of the shells of the west coast of the United States, Mexico, and Central America, by the same author.

4. Bibliography of North American conchology, by W. G. Binney.

5. Descriptive catalogue of the air-breathing shells of North America, by the same author.

6. Catalogue of North American crustacea, in the museum of the Smithsonian Institution, by W. Stimpson, M. D.

7. Catalogue of the described Neuroptera of North America, by Dr. H. Hagen; edited by P. R. Uhler.

8. Classification of the Coleoptera of North America, by Dr. John L. Le Conte.

9. Descriptive list of the diurnal lepidoptera of North America, by Dr. J. G. Morris.

10. Descriptive catalogue of the hymenoptera of North America, by H. De Saussure.

11. Descriptive catalogue of the diptera of North America, by Dr. Dr. H. Loew and Baron Osten Sacken.

12. Catalogue of North American orthoptera, hemiptera, and homoptera, by P. R. Uhler.

Most of these are nearly completed, and will be published during the year 1861.

The thanks of the Institution are due to the gentlemen whose names have been mentioned in connection with the preparation of the several works just mentioned, since their labors have been bestowed for the advance of science, without any other reward than that which might flow from the reputation justly due to the authors of such productions.



The works on insects have been prepared especially to facilitate the study of this branch of natural history—a taste for which has much increased in this country of late years, principally through the exertions of the Smithsonian Institution; and it is believed that, with the growing enthusiasm manifested for this study, specimens of nearly all the species which inhabit North America will soon be collected and accurately described. The practical bearing of a knowledge of entomology, in its application to agriculture and the arts, as well as in its scientific relation to general zoölogy and physical geography, have been pointed out in previous reports. I may mention, however, as an interesting fact exhibiting the relation of animal life to the peculiarities of climate and soil in different parts of the world, that Baron Osten Sacken has ascertained that the same species of insects which inhabit the arid plains of the western portion of our continent are nearly identical with those found on the steppes of Russia.

The next class of publications of the Institution consists of the series of annual *Reports* to Congress. The first reports were in pamphlet form, and merely gave an account of the operations of the Institution and the proceedings of the Regents. Each report, however, since 1853, consists of a volume in which is given, in an appendix, some of the lectures delivered at the Institution, extracts from correspondence, and information of a character suited to the meteorological observers and other persons interested in the promotion of knowledge. The first volume of this series (that for 1853) contains a reprint of all the previous reports of the Secretary, the will of Smithson, the act of organization, and all the facts necessary to a history of the establishment from its commencement. The report for 1859 contains the usual amount of matter, which has thus far been restricted by the action of Congress to 450 pages. The number of copies printed by order of Congress was 10,000, of which only 4,500 were given to the Institution for distribution; whereas, of the report for 1858, the Institution received 7,000 copies. On account of this reduction in the number of copies, we have been obliged to curtail the list of distribution, and to confine it principally to our meteorological observers and to those who have manifested their interest in the work by making special application for it.

In order to ascertain whether the publications of the Institution are received by the persons to whom they are addressed, a printed form of acknowledgment is sent, to be returned with the signature, post office, and occupation of the recipient. The receipts, which have been carefully bound in a series of volumes as vouchers for the faithful discharge

of this part of the operations of the establishment, furnish some interesting statistics as to the occupation, and distribution in the different parts of the country, of the readers of the Smithsonian reports.

*Meteorology.*—An appropriation is annually made by Congress for “the collection of agricultural statistics, investigations for promoting agriculture and rural economy,” &c. Of this, Judge Mason, during his term of office as Commissioner of Patents, devoted a small portion to assist the Smithsonian Institution in collecting and reducing meteorological observations. He considered this kind of information as one of the essential elements on which to found a system of scientific agriculture adapted to the various local climates of the different parts of our extended country, and in his estimates presented to Congress for an increased appropriation, a certain sum was specified as requisite for this important purpose. In his report for 1856, he properly remarks “that the degree of heat, cold, and moisture in various localities, and the usual periods of their occurrence, together with their effects upon different agricultural productions, are of incalculable importance in searching into the laws by which the growth of such products is regulated, and will enable the agriculturist to judge with some degree of certainty whether any given article can be profitably cultivated.” In accordance with these views, an increased appropriation was made by Congress, which has been continued until the present time. The part of the appropriation originally devoted to meteorology was also continued by the successors of Judge Mason, until last year, when it was suddenly and unexpectedly suspended.

The sum thus furnished by the agricultural department of the Patent Office was scarcely more than one third of that appropriated by the Smithsonian Institution. It was, however, of essential service in developing the system and in assisting to defray the heavy expense of blanks and reductions.

The general results of all the observations for six years have been presented in a report to Congress, in the joint name of the Smithsonian Institution and the Patent Office, and are now in the hands of the public printer. The information which is contained in this report is such as is almost constantly called for by the public, and forms a part of the data necessary to base the practice of agriculture upon the reliable principles of insurance, as well as to indicate the climate especially adapted to particular productions. The value, however, of such materials depends upon the number of years during which the observations are continued, and I therefore regret that the late Commissioner of

Patents did not see fit to continue the appropriation which had been made by his predecessors. The system was fully organized and the investigation was considered of too much importance to be abandoned, particularly after so much labor had been bestowed upon it, and therefore it has since been maintained at the sole expense of the Institution. We are sorry, however, that we were obliged to stop the reductions, but hope they will be resumed again before the observations have accumulated to an unwieldy bulk.

The whole system of meteorology is still in a prosperous condition ; the number of observers reporting directly to the Institution is about 500 ; the number of stations reporting to the Surgeon General's office of the War Department is 75. The returns of fourteen stations in Canada are also accessible to the Institution. Observations have been made for the year 1860 at 166 light-houses on the Atlantic and Lake coasts, under the direction of the Light-House Board, copies of which are sent through the Institution to the Board of Trade in England.

The lake system, established under the direction of Captain Meade, of the Topographical Engineers, is still continued. It consists of eighteen stations on lakes Superior, Michigan, Huron, Erie, and Ontario. Each station is furnished with a full set of standard instruments constructed on the plan adopted by the Smithsonian Institution. The observations are regularly taken four times a day at equal intervals of three hours, besides occasional series at certain places at every hour of the twenty-four. The latter are of much value in determining the corrections to be applied to the mean derived from observations taken at a few hours in the day. This system in its extent, the precision of its instruments, and the character of its observers, is one of the most perfect which has ever been established, and if continued for a few years, will give the local climate of the district, with an accuracy which has never been attained in any other part of the continent.

The observations of Lieutenant Williamson, in California, on the hourly fluctuations of the barometer at the level of the ocean and at points on mountain stations, were continued until the end of the last fiscal year, when they were stopped for the want of further appropriations. It is to be hoped the Secretary of War will make provision for renewing these important investigations, since they are not only of great scientific interest, but also of much practical value in correcting the observations for heights by the barometer. Indeed, with the advance of science, a revision of the deductions from all the observations which have been made by the various exploring parties, will be

required, in view of the greater accuracy attainable by the application of corrections derived from observations of this kind.

The Institution has received during the past year a number of valuable meteorological records from officers of the Hudson's Bay Company in different parts of the territory. Among these is a series from Fort Simpson, McKenzie's river, for twelve years, transmitted by B. R. Ross, Esq., chief trader; and another series, for three years, by J. McKenzie, Esq., from Moose Factory, both of which will be continued hereafter. In this connection we may mention that a number of spirit thermometers for marking the extremes of cold have been distributed, through the agency of Mr. Kennicott, to some of the most distant posts of the Hudson's Bay Company.

The daily telegraphic dispatches of the weather from different parts of the country have been kept up with considerable regularity from the South as far as New Orleans; but we regret that frequent intermissions take place in the receipt of the telegrams from places directly west of the city of Washington, especially as we are more immediately interested in these, since they afford the means of predicting with considerable certainty the character of the weather sometimes a day or more in advance.

Besides the sources we have mentioned from which meteorological records have been obtained, an account of others from which communications on the same subject have been received, is given in the special appendix to the Secretary's report. The amount of climatic materials relative to different parts of the continent of North America which has been collected by the Institution is of great value; but it cannot be rendered fully available for general use without a larger expenditure of money than can be devoted to this object by the Smithsonian income.

All the accounts collected by the Institution of the remarkable auroras of August and September, 1859, were placed in the hands of Professor Loomis, and by him discussed and published in the "American Journal of Science."

During the past year, meteorological instruments have been furnished to two expeditions under the direction of the Coast Survey to observe the great solar eclipse of the 18th of July, 1860. One of these was sent to Labrador under the charge of Professor S. Alexander, of the College of New Jersey, and the other to Washington Territory under Lieutenant Gilliss. The instruments, in both cases, have been returned in good condition.

A full set of meteorological instruments and other apparatus has

been furnished to Dr. I. I. Hayes, who has undertaken a new exploration in the Arctic regions for the purpose of gaining additional information as to the existence of an open sea. It is probable that Dr. Hayes will spend the present winter at some point on the coast of Greenland; and if he should do so, he has promised to make good use of the instruments and to adopt measures by which the records of the observations may be transmitted to Washington.

The summer of 1860 was rendered remarkable by the occurrence of a number of tornadoes in different parts of the northern and western portions of the United States. Some of these were of so peculiar a character, and their destructive effects were so extensive, that it was thought a matter of sufficient importance to adopt means for their special investigation. For this purpose it was deemed advisable to send a competent observer to make an accurate survey of the region passed over by the meteors, and to collect all the facts which might tend in the least degree to throw light upon the character of these terrific visitors. The person chosen for this service was Mr. W. L. Nicholson, of the United States Coast Survey, who undertook the investigation for the sake of science; his actual expenses alone, exclusive of transportation, being paid, and a free passage having been secured for him by the Institution through the commendable liberality which characterizes the acts of many of our railroad companies.

The most violent of these storms was that of June 3, in Iowa and Illinois, which swept over more than 600 miles, destroying three towns and perhaps two hundred persons, besides domestic animals and other property to a large amount.

In regard to these remarkable disturbances of the atmosphere, Mr. Nicholson collected a great number of interesting facts, by personal inspection of the effects which still remained, from oral information derived from many eye witnesses, and from actual surveys of the paths of the tornadoes and the relative position of the more prominent objects which remained strewed in their course. These will all be presented in proper form to the Institution as a report of actual facts; and it is proposed by the Secretary to discuss the phenomena in connection with the various theories which have been advanced to explain the origin and progress of storms of this character. Attention was not exclusively confined to meteorological phenomena, but was extended to the physical and other peculiarities of the regions visited; and Mr. Nicholson endeavored to diffuse a taste for meteorology among the people, which it is hoped will in the future supply some vacancies in our corps of observers. He warmly expresses his gratification on account of the

liberality with which he was aided, the general appreciation of the objects of the Institution, and the courtesy everywhere extended to him personally.

It was mentioned in the last report that a commencement had been made, in connection with the Coast Survey, in the preparation of a hypsometrical map of the United States, and that the elevation of upwards of 9,000 points had been collected. This work has been continued during the past year, and efforts have been made to obtain materials existing in the offices of various railroads and public works, and it has been deemed desirable still further to prosecute the research among the archives at the State capitols. About 4,000 additional elevations have thus been obtained, and considerable progress made in the plotting of the material on the sheets of the hypsometrical map.

In furtherance of the same object, a small appropriation in addition to the previous loan of instruments has been made to Prof. Guyot, to assist in a hypsometrical survey of the Apalachian chain of mountains. During the last two or three years, this accomplished geographer has spent a considerable portion of the summer in North Carolina, and has now nearly ready for publication a map of the part of the Apalachian system in that region. He has extended a net work of triangles over an area of nearly 150 miles in length, and determined within these, by a series of contemporaneous barometric observations, the heights of all the more important peaks.

In the report of his labors to the Institution, Professor Guyot makes the following remarks: "I only deplore the absence of points the position of which is determined astronomically or otherwise with sufficient accuracy to enable me to locate my survey on the right spot of the surface of the globe. The existing maps are very deficient in every respect." In connection with this subject, I may be permitted to express the hope that Congress will in due time make provision for extending the system of triangulation which has been established with so much labor and precision along the sea-board to the interior of the continent. The necessity of such a work must every year become more and more evident, as the value of land increases and the precise definition of political boundaries becomes more important.

*Ethnology.*—Whatever relates to the nature of man is interesting to the students of every branch of knowledge; and hence ethnology affords a common ground on which the cultivators of physical science, of natural history, of archæology, of language, of history and literature,

can all harmoniously labor. Consequently, no part of the operations of this Institution has been more generally popular than that which relates to this subject.

From the preceding reports, it will be seen that the Institution has endeavored especially to promote that part of the general subject of ethnology which relates to language; and as in this an increasing number of the intelligent public is interested, the publication of the Dakota and Yoruba grammar and dictionary was received with much favor, and more numerous applications have been made for copies of these works than for almost any others which have been issued by the Institution. Indeed, the entire edition of the Dakota grammar and dictionary, except the copies bound up in the volumes of the series of contributions, has been exhausted. The work has not only been considered of value to the students of ethnology, but also to the officers of the government, missionaries, and others who have been called upon to hold intercourse with our western Indians.

During the past year several works of the same class have been offered to the Institution for publication. Some of these, however, were not in a condition to be printed without revision and philosophical arrangement; and since the death of the lamented Professor Turner, we have experienced difficulty in finding a person of the peculiar skill and learning required for the undertaking of so responsible and difficult a work. We have, however, referred several of the articles presented to us to the American Oriental Society, and have been favored with the advice and assistance of the officers of that association, in enabling us to decide on the disposition of such works; and among these, the Institution is particularly indebted to Prof. W. D. Whitney, of Yale College, for the important service he has rendered us in this line.

Several of the grammars and dictionaries which have been presented were approved, and would have been published by the Institution, had not other means been provided for giving them to the public more expeditiously. Among these, are a grammar of the Grebo language by Bishop Payne, of Africa, which will be printed by the American Oriental Society; and also a Creek grammar and dictionary prepared by Mr. Buckner, and about to be published by the Baptist Missionary Board.

Much interest has been manifested by the students of ethnology in everything which relates to the Indians of the Pacific coast of North America; and the Institution is accordingly desirous to collect all the reliable information on this subject which it can possibly obtain. In

this labor it has been much assisted by Alexander S. Taylor, Esq., of Monterey, California, through whose instrumentality we have received a collection of original manuscripts, of which the following is a description :

1. A vocabulary of the Mutsun Indians of San Juan Bautista, by Padre Felipe Arroyo, consisting of ninety-two folio pages, written in 1815, and sent to the Institution by the Rev. John Cuenelias, of Monterey.

2. A grammar of the same language by Arroyo, also written in 1815, and found at the mission of Santa Ynez, in Santa Barbara county, by the Rev. C. Rubio, principal of the college of that place, by whom it is lent to the Institution. This grammar was copied from Arroyo's manuscripts, in a small octavo of seventy-six pages, in a clear beautiful hand, by one of the friars, and is a curiosity of its kind. It had been hidden at the old mission where Father Arroyo died, for over forty years.

3. An extensive vocabulary of the Indians of San Antonio Mission, of about ninety quarto pages, prepared by Padre Buenaventura Sitgar, one of the original founders of California, and Padre Miguel Pieras, between 1771 and 1797.

4. A catechism of the Chalonese language of the mission of Soledad, written out by Father Vincente Fio de Sarria about 1819, was also found at San Antonio Mission, and forwarded, with the vocabulary of Sitgar, by Rev. D. Ambris, curate of Monterey.

5. A catechism in the language of the San Antonio Mission, with a Spanish translation written by Friar Pedro Cabot, in 1817. This was copied from a wooden tablet used by the missionaries to instruct the Indians at church, and was presented to the Institution by Mr. Taylor, according to whom, Friar Cabot was one of the best educated Spanish missionaries, and justly celebrated among the people of the country for his piety and excellence of heart. He died about 1836.

We are informed by Mr. Taylor that, at his earnest request, one of the learned professors in the college of Santa Clara has undertaken, in behalf of the Institution, to prepare a vocabulary and grammar of the language of the Flat Head Indians of Oregon, among whom he labored as a missionary for many years.

The Mutsun vocabulary has been carefully copied, at the expense of the Institution, by Mr. Cotheal, of New York, and the original returned to the reverend gentleman to whom we are indebted for its use. The other articles mentioned, which are not given to the Institution, will also be copied, and the originals returned. In this way, these



valuable contributions to philology, if not printed, will be preserved and rendered more accessible to the ethnological student.

At the suggestion of Mr. Taylor, we have prepared a circular addressed to the Catholic clergymen, missionaries, and institutions of California, Oregon, Washington, Vancouver's Island, British Columbia, Utah, Arizona, and New Mexico, asking for copies of all Indian vocabularies, grammars, catechisms, and other philological materials, made or collected by the priests who labored among the aborigines, and which, we are informed, are still to be found in many of the mission stations. In Alta California alone, it is said that there are twenty-one missions, in which are preserved books of baptisms, marriages, and deaths of the Indians from 1769 to 1846.

Mr. George Gibbs, formerly of New York, during a residence of twelve years on the Pacific coast, has devoted much time to collecting materials for the illustration of the ethnology of the country. He has obtained over fifty vocabularies of the various languages and dialects spoken along the coast from Behring's straits to San Francisco, and further south; many of which are accompanied by special memoirs by intelligent gentlemen residing among particular tribes or families, and who are well acquainted with their respective idioms. Mr. Gibbs is at present engaged in arranging his materials with a view to present them to this Institution. By the collection and publication of all the materials of this class which can be obtained, additions may be made of importance to the ethnologist, in solving many questions as to the general philosophy of language, and the connection of the different families of American Indians with each other and with different races of mankind.

A considerable number of answers have been received to the circular addressed by the Institution to the foreign agents of the government, missionaries, and other persons in all parts of the world, relative to the investigation as to the system of relationship adopted by different tribes, nations, and races of mankind, mentioned in the last report, as undertaken by Mr. Morgan. These letters have been sent to Mr. Morgan, who has, in turn, acknowledged his indebtedness to the Institution for the valuable aid rendered him in the prosecution of his research.

Some years ago a memoir was submitted to the Institution, on the physical peculiarities of the European man in America, by a gentleman of Cincinnati, which was found to contain a large amount of interesting matter, but scarcely sufficient data to warrant a safe induction as to the subject of investigation. A similar inquiry has been insti-

tuted by members of the Academy of Natural Sciences of Philadelphia, and in coöperation with these, a circular has been issued by the Institution, asking for statistics relative to the place of birth, country of parentage, profession or occupation, age, height, and weight of native-born American citizens. To this circular about one hundred answers have been returned from our meteorological correspondents, the whole series furnishing the facts relative to about two thousand individuals. It is intended to present the statistics thus obtained to the author of the memoir above mentioned, as well as to the Academy of Sciences. It will, however, be evident, on reflection, that the value of such statistics must depend on the number of cases which they include, and the length of time through which they are continued; since it is highly probable that the changes produced by climate and other conditions of existence, become marked only after a succession of generations have been exposed to the modifying influences.

The Institution continues to receive from time to time, information respecting the existence of mounds and other remains of the original inhabitants of this continent not previously described, and since the proposition has been entertained of preparing a map to illustrate the relative distribution of these remains, all information of this kind will be very acceptable.

A paper has been some time in possession of the Institution, on the mining operations of the ancient inhabitants of the region around Lake Superior, but it is not yet in a sufficiently elaborate condition to be presented to the public through the Smithsonian Contributions. We hope, however, that in the course of the year we shall be able to have it revised and prepared for the press. It may be proper also to mention, in this connection, that a large number of crania of different tribes of Indians, as well as of different races of men, has been collected together at the Institution, the study of which would probably furnish some new facts of interest to the ethnologist.

*Magnetic Observatory.*—It was stated in the last report that, as the changes in the direction and intensity of the magnetic force at Toronto were found to be almost precisely the same as at Philadelphia and Washington, it had therefore been concluded that more important service could be rendered science by making the observations at a greater distance from Toronto than the grounds of the Smithsonian Institution. In accordance with this conclusion, the instruments of the observatory, jointly supported by the Smithsonian Institution and the Coast Survey, have been sent to Key West, where the United States government has a fortification, and the Coast Survey maintains

a tidal station. Key West is situated in latitude  $24^{\circ} 33'$  north, longitude  $81^{\circ} 41'$  west, and is a low coral island, rising at no point more than ten or twelve feet above the sea. The mean temperature of the spring is  $75^{\circ}$ , of summer  $82^{\circ}$ , of autumn  $78^{\circ}$ , and winter  $69^{\circ}$ . The daily variation of temperature is therefore very small, and on this account as well as from its position, the island is well adapted to magnetic observations.

The observatory is situated on the grounds of the government, a few hundred yards from Fort Taylor, and near the water. A large shed belonging to the fort was made use of, by permission of the engineer department, as an outer protection for an inner building containing the instruments. The inner rooms were properly inclosed in a substantial manner, leaving a clear space between their walls and those of the outer building for the free circulation of air. The piers supporting the instruments rest upon the solid rock of the island, and are therefore subject to no other changes than those which result from the slight annual variation of temperature. A small building to the north of the observatory was erected for the instruments employed to determine the absolute values of the magnetic elements, to be used in connection with the continuous photographic records of the variations.

The instruments were mounted at Key West in January and February, 1860, by Prof. W. P. Trowbridge, assistant in the United States Coast Survey, and a series of observations commenced by this gentleman, assisted by Mr. Samuel Walker, in March, have been continued to the present time, under the charge of Mr. George D. Allen, who is now retained as permanent observer. The expense of the observations is sustained jointly by the Smithsonian Institution and the Coast Survey. In the appendix to the last report will be found a minute description of the self-recording instruments here referred to, and of the method of using them, prepared by Mr. J. E. Hilgard; and in the appendix to the present report it is proposed to insert a communication from Gen. Sabine to the Royal Society of London, giving a brief exposition of the laws of the phenomena of the larger magnetic disturbances, as far as they have been ascertained, and of the interesting contributions to science which such observations as are now made at Key West may be the means of affording.

*Laboratory.*—During the last year the laboratory has remained under the direction of Dr. B. F. Craig, of this city, and, as in former years, many minerals from different parts of the country, submitted to the Institution for examination, have been reported upon. It

may be proper here to repeat the statement which has previously been made as to the policy adopted in regard to examinations of this kind, namely: to furnish an account of the character of the minerals free of cost to the parties asking the information, provided it is of general interest, or immediately connected with the advance of science, and can be afforded at little expense to the Institution. If, however, the information required is for private interests, a charge is made sufficient to cover the expense of the investigation. By the adoption of this policy, the laboratory has been kept in operation by means of a small annual appropriation for chemicals and apparatus.

*Collections of Natural History, &c.*—The Smithsonian Institution, during the twelve years of its active existence, has expended a large amount of labor and money in collecting and preserving specimens of geology, natural history, and ethnology, and has also received the entire charge of all the specimens collected by the various expeditions of the general Government. The scientific material thus collected is very valuable, and, in number and variety of specimens and duplicates, to illustrate the natural productions of the North American continent, far excels any other collection ever made. It is not the policy of the Institution to hoard up specimens for the exclusive study of those immediately connected with the establishment, or to consider the duplicates merely as articles of commercial value, only to be exchanged for marketable equivalents, but to render them available as widely as possible for the advance of knowledge. In accordance with this policy, arrangements have been commenced for a more general distribution of the type and duplicates, and for the description of new species, than has heretofore been practicable.

The specimens may be divided into two classes: first, those which have been described in the reports of the Government expeditions, or in the transactions of the Smithsonian and other institutions; and second, those which have not yet been described, and which consequently are considered of much value to the naturalists who desire to gratify the laudable ambition of connecting their names with original accounts of new species, or who are engaged in preparing monographs of particular families. Of both classes the Institution possesses an immense number of duplicates, in the disposition of which, some general principles should be kept constantly in view. After due consultation and deliberation the following rules for the first class, and considerations for the second, are proposed.

First. To advance original science, the duplicate type specimens

should be distributed as widely as possible to scientific institutions in this country and abroad, in order that they may be used in identifying the species and genera which have been described.

Second. To promote education, as full sets as possible of general duplicates, properly labeled, should be presented to colleges and other institutions of learning that profess to teach the principal branches of natural history.

Third. It should be distinctly understood that due credit is to be given to the Institution in the labeling of the specimens, and in all accounts which may be published of them, since such credit is not only due to the name of Smithson, but also to the directors of the establishment as vouchers to the world that they are faithfully carrying out the intention of the bequest.

Fourth. It may be proper in the distribution to institutions abroad, as a general rule, to require, in case type specimens to illustrate species which have been described by foreign authors may be wanted for comparison or other uses in this country, that they be furnished at any time they may be required.

Fifth. In return for specimens which may be presented to colleges and other educational establishments, collections from localities in their vicinity, which may be desirable, shall be furnished when required.

The disposition of the undescribed specimens in the collection of the Institution is a matter which requires special consideration, and involves in every case of application for the use of them the necessity of deliberation to guard against the falling of the specimens into improper hands, and prevent as far as possible the charge of favoritism.

It is not impossible that in some cases, hasty and imperfect descriptions have been published of specimens belonging to the Institution, through the desire of the author to connect his name with a new species, rather than from an honest endeavor to advance knowledge. It would, however, have been difficult to refuse any person the privilege of examining new species, who professed to be actuated alone by the desire of having an opportunity of laboring in a particular field of investigation; but it is clear that special encouragement and preference should be given to those who undertake the more difficult and laborious task of forming complete monographs.

It is not in accordance with the policy of the Institution to subject a person who is engaged in a special line of research, to the expense of residing in Washington during the period perhaps of many months required for the investigation, but, when necessary, he is allowed to

take the materials to his home to study them at his leisure, provided the Institution is satisfied as to his competency, his integrity, and industry. But in granting this privilege, some restriction should be put upon the time the specimens may be retained by the investigator, and also upon the number he may have at once in his possession. He should also give assurance that he will prepare a set of type specimens properly labeled for preservation in the Smithsonian museum, and that all the duplicates, if required, shall be returned to the general collection.

The proper distribution of the duplicate specimens is a work of great labor and expense. It does not consist merely in assorting and packing them for transportation, but also in properly numbering and labeling them for immediate use. Without these preliminaries, the specimens themselves would be of comparatively little value. For example, we may send to an educational establishment a series of specimens, many of which are to be found in its immediate vicinity, and yet be of great value on account of having attached to them the scientific names by which they are known to men of science in every part of the civilized world, and without which all that may be stated in regard to them in books would have no interest for want of certainty as to the identity of the objects described.

To illustrate the details of the system of distribution, I may mention the plan adopted in regard to the shells and minerals. Of these, a complete series, consisting of a full representation of each species, is in the process of being accurately labeled, and when this work is completed, the whole collection of duplicates will be assorted in boxes or bins, each apartment containing those belonging to the same species. Each shell or mineral in the same box will then be marked with the same number, corresponding with a number on a list of printed labels, two copies of which will be sent to each recipient of a collection; one to be preserved for reference and the other to be cut up into labels to be attached to the specimens. After this preparation and arrangement, individual series are made up by taking a single specimen from each box. This operation demands a critical knowledge of each particular class of specimens, and consequently requires the coöperation of a number of experienced naturalists, each an acknowledged authority in his special department.

From the foregoing account it must be clear that the labor and time required even to prepare a few sets of specimens for distribution, is much greater than at first sight might be imagined; and since the number of suites of specimens in the Smithsonian collection amounts in some cases to several hundred, it is evident that the expense must

exceed the unaided means of the Institution, unless the time of completing the distribution be extended over a number of years.

In accordance with the plan described, a commencement has been made in the work, preparatory to the general distribution. The assortment and labeling of an entire set of shells has been principally intrusted to Mr. Philip Carpenter, of Warrington, England, one of the first conchologists of the day, who has prepared a report on the shells of the northwest coast of the United States for the British Association. In this work Mr. Carpenter has been assisted by the gratuitous labor of Mr. Isaac Lea, Dr. A. A. Gould, Dr. E. Foreman, Mr. W. G. Binney, Dr. W. Stimpson, and Mr. Temple Prime.

The botanical collection has been placed in the hands of Dr. John Torrey, of New York, who has generously offered, with the coöperation of Dr. Gray, of Harvard University, to superintend the labeling of a complete set of specimens to be preserved in the museum of this Institution, of several sets of original type series, to be presented to some of the principal museums of this country and of Europe, and the preparation of the remainder for distribution to colleges and academies.

The arrangement of the specimens of the other branches of natural history has been commenced and laboriously prosecuted under the direction of Professor Baird, who has been assisted especially by Dr. H. Bryant, Mr. Theodore Gill, and a number of amateur naturalists.

In accordance with the policy of rendering the collections of new material immediately available for the advance of science, a number of series of specimens of different genera and species have been intrusted for study and description to different gentlemen interested in special branches of natural history. The service which has been rendered the cause of natural history by this liberal course is far greater than might at first sight appear.

It may be safely asserted that scarcely any extended investigation in the line of natural history has been prosecuted in this country during the last ten years without having its material in greater or less part furnished by the Institution.

*Explorations.*—During the past year the collections have been increased by a number of expeditions under the direction of the different departments of the general government, and by explorations in part at the expense and under the direction of the Institution. Of these a detailed history is given in the report of Professor Baird herewith presented, and it is only necessary for me in this connection to mention some of the latter sources of the increase of specimens.

Mr. Robert Kennicott, the enterprising young naturalist mentioned in the last report, has continued his explorations in the Hudson's Bay territory and Russian America, and his labors have, as in previous years, received the cordial coöperation of all the officers and agents of the Hudson's Bay Company. Not only has he been permitted to visit and reside at the different posts, but he has received free transportation of himself and collections. Mr. Kennicott will further extend his explorations into Russian America, and will probably remain absent until the autumn of 1863.

Mr. John Xantus, whose name has also been mentioned in some of the previous reports, has industriously occupied his time not devoted to tidal observations for the Coast Survey at Cape St. Lucas, in Lower California, in completing the collections of the natural history of that region. The specimens he has obtained on the western coast are greater in number and variety, according to Professor Baird, than those ever collected in that region by any single individual.

Mr. C. Drexler, under the special direction of the Institution, during the last year made an exploration in the region of James' Bay, and in this case also the Hudson's Bay Company liberally seconded the objects of the Institution. He was enabled to collect a large number of valuable specimens through the facilities afforded him, and these were sent from Moose factory to London, at the expense of the company; and thence to this country by the Cunard steamers, free of charge; acts of liberality which deserve to be specially noticed, not only as examples of gratifying appreciation of science, but also of the efforts of the Institution to enlarge its boundaries.

*Museum.*—What has been said under the head of collections may serve to illustrate the service which the Institution might have rendered to natural history without having established a public museum, and incurred the expense of the erection of a large building and the continued cost of supporting its necessary establishment of numerous employés. The act of Congress, however, authorized the erection of a building for the reception of objects of natural history, under the idea, then prevalent, that such a provision was absolutely necessary for carrying out the will of the testator; but it must be clear to every one who critically examines the subject that, unless restricted, the expense of making provision for a general museum alone would absorb all the funds, and thus confine to a single object, and that principally local in its effects, the bequest intended for the increase and diffusion of knowledge generally among men.



If the duplicates now in possession of the Institution were to be distributed on the plan of demanding an equivalent of specimens in exchange, the returns would fill far more than the unoccupied space now in the Smithsonian building, and an additional edifice would be required, the cost of which would either diminish the original fund or absorb for years to come the accruing interest. It is evident, therefore, that unless the museum be restricted within definite limits, the active operations which have given so much reputation to the Institution, and made the name of Smithson as familiar as a household word in every part of the world, must ultimately cease. It has, therefore, been concluded to confine the special collections of the Institution to type specimens, illustrating the natural history of the American continent. Even the cost of the preservation of these will be more than can well be afforded from the income of the original bequest. Indeed the Institution could do much more service to the cause of natural history, were Congress to accept as a gift the Smithsonian building and all its specimens for the purpose of establishing a separate museum, and suffer the Smithsonian income, thus freed from the expense of supporting so costly an establishment, to be entirely devoted to the active operations of the programme of organization.

It is not intended by the foregoing to decline accepting foreign specimens in cases in which they may be required for special investigation and comparison; on the contrary, it is a part of the policy of the Institution to furnish, as far as possible, to original investigators aid of this kind.

For an account of the labors connected with the collections and the museum, in detail, I must refer to the communication, herewith appended, of Professor Baird.

*Exchanges.*—The system of exchange still continues to perform an important part in the literary and scientific intercourse between this country and other parts of the world. During the year 1860 it has increased more rapidly than in any other period of the same length, and is now the principal medium of literary and scientific communication between the American continent and foreign countries. It is not confined on this side of the Atlantic to the United States, but extends to Canada, the West Indies, and South America.

As a natural consequence of the extension of this part of the operations, the cost of carrying it on has correspondingly increased, and it will be impossible with the limited income of the Smithsonian fund to enlarge the system, or even to continue it in its present dimensions,

without a *pro rata* assessment of at least a portion of the expenses on the different parties who avail themselves of its facilities. The expense of the system of exchange would, however, be far greater were it not for the many favors we receive from transportation companies, either in a great reduction of charges or their entire omission. For conspicuous examples of this liberality, the Institution may refer to the Cunard steamers between New York and Liverpool, to the North German Lloyd between New York and Bremen, the Pacific Mail Steamship Company, Panama Railroad Company, North Atlantic Steamship Company, the Adams Express Company, the steamship Isabel line between Charleston and Havana, and Russell's army transportation lines, and also to the Hudson's Bay Company.

The whole number of large packages containing books, specimens, and other articles received at the Institution from different parts of the world during 1860, was 1,000; the number of packages of the same character sent off was 888. When it is recollected that each of these packages contained a large number of articles, all of which were to be distributed, while those intended for this Institution were to be catalogued and acknowledged, some idea may be formed of the labor required to carry on this single branch of the general operations of the establishment. For a detailed statement of the particulars relative to this branch of the general operations, I must also refer to the report of Professor Baird.

*Library.*—Since the presentation of the last report, the plan adopted in regard to the increase of the library has been steadily pursued, namely: to obtain as perfect a series as possible of the transactions and proceedings of all the learned societies which now exist or have existed in different parts of the world. The distribution of the catalogue of the works of this kind already in the library, which was mentioned in the last report, with the request that our deficiencies might be supplied, has called forth the presentation of a large number of scarce volumes, intended to complete the sets, as well as to increase the number of our series. During the last year the Institution has received from abroad, for its own library, by way of donation and exchange, upwards of 5,000 presentations, consisting principally of volumes and parts of volumes.

The distribution of the same catalogue through this country has served to render more generally known the works contained in the library of the Institution, and has consequently increased its use. The value of this library will, however, be greatly enhanced by the

publication of the classified index of all papers contained in the transactions of learned societies and in scientific serials, now in process of preparation at the expense and under the direction of the Royal Society of London. The following extract from a letter lately received from General Sabine gives an account of the character and present condition of this work:

“Our plan comprehends natural history as well as what are usually called the exact sciences. It is intended to form three distinct catalogues: first, a catalogue of all the serials included in the publication, with the contents of each in chronological order; second, a catalogue of all the separate memoirs in all the serials, alphabetically arranged according to the authors' names; third, a classified catalogue of the separate memoirs. The two last named catalogues to contain, in addition to serials, distinct scientific memoirs in the appendices to voyages, travels, &c. We have written in quadruplicate the titles of above 80,000 detached memoirs, all from works (serials) in our own library. We have still in the library more serials, which will give us about 80,000 more titles, which we expect will be the work of the next fifteen or sixteen months. In the mean time we are seeking out for, and adding to, our library, works of the same nature which we do not possess. In this we think you could greatly assist us by lists of American publications—serials of course.”

The Institution should contribute in every way in its power to this important work, and should endeavor, when it is printed, to make arrangements by which copies may be obtained at a small expense for the principal libraries of the country. In the way of contributions of some importance to this great enterprise, we hope to be able, in a short time, to furnish the bibliography of North American mammals, birds, several orders of insects, shells, and plants; and to complete, at no distant period, the whole series relative to the natural history of this continent.

The first volume of the catalogue of zoölogical literature from 1750 to the present day, by J. Victor Carus, of Leipzig, mentioned in the last report, has been published; and we would commend it to the patronage of naturalists as the best compilation which has yet appeared of the titles systematically arranged of isolated papers on zoölogy published in American as well as foreign journals.

Among the special donations since the date of the last report, are 151 volumes from the Royal Library at Munich, and 193 from the University at Olmutz; 60 from the British Museum, 30 from the Royal Society of Amsterdam, 25 from the Royal Society of Upsala, 28 from the University of Utrecht, and 36 from the Royal Observatory at Vienna.

The donation from the Royal Library of Munich, mentioned above, is a part of a large invoice of rare and valuable works, including many incunabula, for presentation to different specified libraries in the United States, after this Institution should have made its selection.

The purchases have been chiefly in the way of completing such series of transactions as could not be obtained by exchange, and of works necessary to the investigations connected with the Institution, such as those on natural history, meteorology, &c.

About one third of the expenditure under the head of "cost of books," given in the report of the executive committee, is for binding—an item of expense which is every year increasing with the number of serials received through our exchanges; the current volumes of this kind being usually distributed in paper covers. Since the date of the last report, all the scientific pamphlets have been classified according to subjects, and placed in the hands of the binder.

The policy adopted in regard to the library, as we have said, is that of rendering it a special collection, as complete as possible in transactions, proceedings of learned societies, and other scientific serials; and since the space which can be devoted—without further extension of the building—to the increase of this and other collections is limited, it has been thought proper to present to the American Antiquarian Society a large accumulation of newspapers in exchange for works more immediately in accordance with the design of the Institution, and with one of the fundamental propositions of the programme of organization, viz: that of doing nothing with its funds which can be done equally well or better by other means. While the care of these ephemeral publications would be troublesome and expensive to the Smithsonian Institution, it forms a legitimate part of the duty of the Antiquarian Society, which has a considerable fund expressly devoted to the purpose. This disposition of the papers, many of which have been presented to the Institution, is not made on account of a want of proper appreciation of their value; on the contrary, we fully agree with the opinion expressed by Mr. Haven, the learned librarian of the Antiquarian Society, "that even partial series, when properly arranged, constitute a geographical and historical chart of public sentiment, and of social and political facts, in which sectional and denominational diversities, of whatever kind, are brought under a single view for examination and comparison." They have been presented to the Antiquarian Society that they may better subserve this object, and in the spirit of coöperation which characterizes the policy of the Institution.

*Gallery of Art.*—The large and valuable collection of paintings of Indian portraits and scenes of Indian life belonging to Mr. Stanley, and those of the Government, have continued to form an object of attraction and interest to the numerous visitors of the Institution. The large room in which these pictures are displayed has been furnished with cases to contain the specimens of Indian costume, implements of war, and other articles to illustrate Indian manners and customs, which the Institution has received as presents from different parties.

No application of late has been made to Congress for an appropriation to purchase the valuable collection of Indian portraits belonging to Mr. Stanley, although it is hoped that in a more favorable condition of the Treasury an appropriation for this purpose will be granted.

At the last session of the board a letter from Professor Secchi, of Rome, was read, stating that he had obtained permission for the Institution to procure casts or moulds of celebrated statues in the Vatican, but it was concluded that all operations in this line should be deferred until the completion of the large and elegant building now in process of construction by Mr. W. W. Corcoran, of this city, to be devoted by him to the exhibition of works of art. In accordance with the policy adopted by the Institution, it has been proposed to coöperate with Mr. Corcoran in his liberal and generous enterprise, and to lend the influence of the Institution in procuring specimens of art for his gallery.

A considerable number of valuable engravings have been added to the collection by donations from the King of Saxony, and a series of those previously in the possession of the Institution, have been framed and hung up in different parts of the building. The plaster figures received by the Institution from the Patent Office have been cleaned and repaired, and are now exhibited in the connecting range of the west wing. The Secretary of the Interior has sent to the Institution the large stone sarcophagus brought from Syria by Commodore Elliott. It is an interesting relic of Roman sculpture, and has been placed in the south entrance hall of the building. It is proper also to mention that the relatives of the late Professor Espy have presented a half length portrait of him, which is at present placed in the library.

*Lectures.*—In accordance with the programme of the Institution, the following courses of lectures have been given to the citizens and visitors of Washington, during the winter of 1860–61, namely:

Five lectures by Professor FAIRMAN ROGERS, of the University of Pennsylvania, on Civil Engineering, Roads and Bridges, and the principles involved in their construction.

One lecture, by Professor P. A. CHADBOURNE, of Williams College, on Iceland.

Five lectures by Dr. F. A. P. BARNARD, President of the University of Mississippi, on polarized light.

1. Outline of optical discovery ; characteristics of polarized light.
2. Undulatory theory of light ; physical doctrine of polarization.
3. Chromatics of polarized light.
4. Physical theory of double refraction, and of polarization by double refraction.
5. Circular, elliptical, and rotary polarization.

Two lectures by Professor STEPHEN ALEXANDER, of the College of New Jersey, on solar eclipses and their attendant phenomena, with a particular account of the total eclipse of last July, and the observations made in connection with it by the Government expeditions to Labrador, the Pacific coast, and elsewhere.

Three lectures by S. WELLS WILLIAMS, on China and Japan.

1. The literature and government of China.
2. The civilization of the Chinese.
3. Rank of the Japanese among Asiatic nations.

Five lectures by Rev. JOHN LORD, of Connecticut, on the great representatives of modern civilization, &c.

1. Michael Angelo and art.
2. Bacon and philosophy.
3. Cromwell and liberty.
4. Madame De Stael and literature.
5. Columbus and discovery.

Beside the foregoing, a series of experimental lectures on physical science has been given by the Secretary of the Institution to the teachers of the District, and others interested in the subject. In these articles of apparatus presented by Dr. Hare, and those purchased for the use of the Institution, were used. During the present lecture season, owing perhaps, in part, to unfavorable weather and the distracted condition of the public mind, the attendance has been less numerous than in former years. The plan suggested in the last report, of closing the doors after the lecture had commenced, has been adopted and found conducive of good order and more prompt attendance.

Respectfully submitted,

JOSEPH HENRY,  
*Secretary Smithsonian Institution.*

FEBRUARY, 1861.

## APPENDIX TO THE REPORT OF THE SECRETARY.

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SMITHSONIAN INSTITUTION,  
*Washington, December 31, 1860.*

SIR: I have the honor herewith to present a report for 1860 of the operations you have intrusted to my charge, namely: those which relate to the printing, the exchanges, and to the collections of natural history.

Very respectfully, your obedient servant,

SPENCER F. BAIRD,

*Assistant Secretary Smithsonian Institution.*

Prof. JOSEPH HENRY, L.L. D.,

*Secretary Smithsonian Institution.*

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### PRINTING.

The publications of the Institution printed during the year 1860 consisted of 614 quarto and 644 octavo pages, illustrated by seven plates and sixty-six wood cuts.

### EXCHANGES AND TRANSPORTATION.

During the year 1860 there has been a very great extension of all operations connected with the department of exchanges. The receipts by the Smithsonian Institution have been much enlarged over those of any previous year, and an increased use has been made by other parties of its facilities both for the transmission and return of packages.

The following tables will be found to exhibit the statistics of this branch of operations of the Smithsonian Institution, showing how important a part it plays in aiding the scientific and literary intercourse of different parts of the globe.

The expense of the system of exchanges, however, has been correspondingly increased, and would have been greater than the Smithsonian income could defray without the many favors from transportation companies, in the way of material reduction or entire remission of charges.

for freights. The benefits resulting from such liberality have of course been experienced by all departments of operations, but chiefly in that of exchanges and of the collections. The parties to which the Institution is chiefly indebted are as follows:

The North German Lloyd, a line of steamships between New York and Bremen, of which Messrs. Gelpcke, Keutgen, and Reichelt, of New York, are agents. The Pacific Mail Steamship Company, between San Francisco and various ports of Oregon and Washington, to the north, and Panama to the south; of which Mr. W. O. Davidge was president for a time—succeeded by Mr. Allen McLane. Also, the Panama Railroad Company, Mr. David Hoadley, President. The steamer connection with California was, at the date of the last report, formed by the North Atlantic Steamship Company, Mr. I. W. Raymond, President; and the Institution had the privilege of transmitting its exchanges both ways free of charge. Since the new arrangements, by which the vessels of Commodore Vanderbilt replace those of the last mentioned company, this privilege has been somewhat interrupted; the agent of Commodore Vanderbilt declining to continue it between New York and Aspinwall. I am, however, happy to report that no serious interruption beyond a little delay has resulted, as Mr. Hoadley has authorized the free transmission of Smithsonian parcels by the brig line of the Panama railroad between New York and Aspinwall.

To Mr. A. B. Forbes, agent of the Pacific Mail Steamship Company, in San Francisco, aided by Mr. Samuel Hubbard, the Institution is under many obligations, in acting as general agents for it in California.

The great facilities authorized by the Adams Express Company, through Superintendent S. M. Shoemaker, and at present exercised by the Washington agent, Mr. McLaughlin, mentioned in the last report, have been continued the past year, greatly to the interest of the Institution.

The Cunard steamers, between New York and Liverpool, have carried many packages free of charge during the year.

In addition to the parties first mentioned, assistance has been rendered, as heretofore, to the exchanges and explorations conducted by the Institution, by the steamer Isabel, running between Charleston and Havana; by Mr. W. H. Russell, army contractor of transportation, and by other parties.

The services of the parties named above have all been gratefully mentioned in preceding reports. To the directors and officers generally of the honorable Hudson's Bay Company, through the late Sir George Simpson, governor in this country, the Smithsonian Institution has to acknowledge its special indebtedness. In addition to the aid afforded to the various enterprises of Hudson's Bay explorations on the part of the Institution, referred to elsewhere, it has carried a very large amount of freight in its canoes, free of charge, consisting of supplies to various points, and returns of meteorological records and specimens of natural history. Without such assistance the expense of conducting scientific explorations in the far north would be so great as entirely to preclude the possibility of any such enterprises on the part of the Institution.



The entire number of packages received at the Institution during 1860, by express, railroad, and steamboat, amounted to exactly 1,000; while 888 were transmitted in the same time; making an aggregate of 1,888. This number, of course, has no reference to the sub-packages or smaller parcels inclosed in larger ones, or in the boxes of exchanges received from the agents of the Institution abroad. The receipts of the same kind in 1859 were 804; the transmissions 845; an aggregate of 1,649, showing an increase of 239, or about one seventh.

## A.

*Receipt of books, &c., by exchange in 1860.*

## Volumes :

Octavo .....	781
Quarto .....	419
Folio .....	71
	<hr/>
	1,271

## Parts of volumes and pamphlets :

Octavo.....	2,716
Quarto.....	1,371
Folio.....	93
	<hr/>
	4,180

Maps and charts .....	220
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Total.....	5,671
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Showing the very great increase over the aggregate (3,602) of last year, of 2,069 volumes and parts of volumes, or nearly as great an amount as the receipts of 1858 and 1859 combined. The number of separate donations was 1,635, to 1,252 of last year.

As a matter of some interest I take the liberty of recapitulating the receipts by exchange in the ten years, during which the system has been in active operation :

1851.....	878	volumes and parts of volumes.
1852.....	609	do.
1853.....	2,556	do.
1854.....	2,828	do.
1855.....	2,770	do.
1856.....	3,330	do.
1857.....	1,760	do.
1858.....	2,540	do.
1859.....	3,602	do.
1860.....	5,671	do.
	<hr/>	
Total.....	26,544	do.
	<hr/> <hr/>	

## B.

Table showing the statistics of the foreign exchanges of the Smithsonian Institution in 1860.

Agent and country.	Number of addresses.	Number of packages.	Number of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in pounds.
<b>1. Dr. FELIX FLUGEL, Leipsic.</b>					
Sweden .....	11	31	.....	.....	.....
Norway .....	6	18	.....	.....	.....
Denmark .....	9	32	.....	.....	.....
Russia .....	27	80	.....	.....	.....
Holland .....	18	63	.....	.....	.....
Germany .....	164	530	.....	.....	.....
Switzerland .....	16	56	.....	.....	.....
Belgium .....	8	25	.....	.....	.....
Total .....	259	835	21	274	6,841
<b>2. H. BOSSANGE, Paris.</b>					
France .....	72	195	.....	.....	.....
Italy .....	32	96	.....	.....	.....
Portugal .....	2	5	.....	.....	.....
Spain .....	5	1	.....	.....	.....
Total .....	111	307	13	174	4,561
<b>3. HENRY STEVENS, London.</b>					
Great Britain and Ireland .....	105	430	22	299	8,327
<b>4. Rest of the world.....</b>					
.....	50	120	5	20	300
Grand total.....	525	1,692	61	767	20,029

## C.

Packages received by the Smithsonian Institution from parties in America for foreign distribution in 1860.

	No. of packages.
<i>Albany, N. Y.—</i>	
Prof. J. Hall.....	9
New York State Agricultural Society.....	16
<i>Baltimore, Md.—</i>	
Dr. P. R. Tyson.....	50
<i>Boston, Mass.—</i>	
American Academy of Arts and Sciences.....	78
Society of Natural History.....	48
F. H. Storer .....	169
Messrs. Storer and Elliott.....	78

	No. of packages.
<i>Cambridge, Mass.—</i>	
American Association for Advancement of Science.....	38
Observatory .....	8
Prof. Asa Gray.....	19
<i>Columbus, Ohio.—</i>	
State Agricultural Society.....	100
W. S. Sullivant.....	15
<i>Danville, Ky.—</i>	
Institution for Deaf and Dumb .....	10
<i>Frankfort, Ky.—</i>	
State of Kentucky.....	150
<i>Montreal, Canada.—</i>	
T. S. Hunt .....	12
<i>New Haven, Conn.—</i>	
American Journal of Science .....	12
American Oriental Society.....	8
Yale College .....	5
<i>Philadelphia, Penn.—</i>	
Academy of Natural Sciences.....	131
American Philosophical Society .....	250
Historical Society of Pennsylvania.....	13
Isaac Lea .....	73
Dr. S. W. Mitchell .....	6
<i>Providence, R. I.—</i>	
State of Rhode Island.....	6
<i>San Francisco, Cal.—</i>	
California Academy of Science .....	17
<i>Toronto, Canada.—</i>	
Canadian Institute .....	11
<i>Washington, D. C.—</i>	
United States Patent Office .....	1,391
United States Coast Survey .....	185
Surgeon General.....	100
Lieut. Warren, U. S. A .....	6
Lieut. J. C. Ives, U. S. A.....	10
<i>Williamsburg, Va.—</i>	
Eastern State Lunatic Asylum.....	12
<b>Miscellaneous.....</b>	<b>94</b>
	<hr/> <hr/> 3,130 <hr/> <hr/>

## D.

*Addressed packages received by the Smithsonian Institution from Europe, for distribution in America, in 1860.*

	Number of packages.		Number of packages.
<i>Albany, N. Y.</i>		<i>Boston, Mass.</i>	
Dudley Observatory.....	7	American Academy of Arts and Sciences.....	74
New York State Library.....	8	Boston Society of Natural History.....	55
New York State Agricultural Society...	17	Historic-Genealogical Society.....	3
New York State Medical Society.....	9	Prison Discipline Society.....	1
Prof. James Hall.....	9	Dr. A. A. Gould.....	3
Albany Institute.....	2	American Statistical Association.....	6
Dr. Brunnow.....	6	Bowditch Library.....	7
Prof. E. Emmons.....	1	Geological Survey.....	1
J. H. Hickcox.....	2	Philosophical Society.....	1
Prof. Peters.....	1	Library of Boston Athenæum.....	1
H. W. Schroeder.....	1	Lyceum of Natural History.....	2
<i>Amherst, Mass.</i>		Massachusetts Historical Society.....	3
Amherst College.....	6	Massachusetts State Library.....	6
Prof. Hitchcock.....	3	Public Library.....	9
Edward Tuckerman.....	1	Francis Alger.....	1
<i>Annapolis, Md.</i>		Dr. S. L. Abbott.....	1
Naval Academy.....	2	Prof. J. W. Bailey.....	1
<i>Ann Arbor, Mich.</i>		Edward Habich.....	1
Observatory.....	4	Prof. Jackson.....	1
University of Michigan.....	1	Charles C. Jewett.....	1
Prof. Brunnow.....	1	Prof. Jules Marcou.....	1
<i>Atlanta, Ga.</i>		Prof. Moreland and F. Minot.....	2
Atlanta Medical and Surgical Journal.....	2	Profs. W. B. and H. D. Rogers.....	4
<i>Bahia, Brazil.</i>		Samuel H. Scudder.....	1
Dr. Fölsner, (Hann. Consul).....	1	<i>Brunswick, Me.</i>	
<i>Baltimore, Md.</i>		Bowdoin College.....	5
Maryland Historical Society.....	6	Historical Society of Maine.....	2
Rev. Dr. J. G. Morris.....	2	Mr. Packard.....	2
<i>Bogota, New Granada.</i>		<i>Burlington, Iowa.</i>	
Societa de Naturalistas Neo-Granadinos.....	2	Iowa Historical and Geological Institute.....	2
<i>Bethlehem, Penn.</i>		<i>Burlington, Vt.</i>	
Rev. Mr. Seidel.....	1	University of Vermont.....	3
<i>Bethlehem, Penn.</i>		George P. Marsh.....	1
<i>Bethlehem, Penn.</i>		<i>Cambridge, Mass.</i>	
<i>Bethlehem, Penn.</i>		American Association for Advancement of Science.....	20
<i>Bethlehem, Penn.</i>		Astronomical Journal.....	7
<i>Bethlehem, Penn.</i>		Cambridge Observatory.....	16
<i>Bethlehem, Penn.</i>		Prof. L. Agassiz.....	41
<i>Bethlehem, Penn.</i>		Prof. Asa Gray.....	17
<i>Bethlehem, Penn.</i>		Harvard University.....	22
<i>Bethlehem, Penn.</i>		G. P. Bond.....	5
<i>Bethlehem, Penn.</i>		James P. Cooke.....	1

D—Continued.

	Number of packages.		Number of packages.
<i>Cambridge, Mass.—Continued.</i>		<i>Columbus, Ohio.</i>	
Charles H. Davis.....	1	Ohio State Agricultural Society .....	42
Dr. B. A. Gould.....	15	John H. Klippart.....	1
Joseph Lovering.....	3	<i>Columbia, S. C.</i>	
Prof. Pierce.....	6	South Carolina College.....	3
S. H. Safford.....	1	State University Geological Rooms.....	2
J. E. Worcester.....	4	Robert W. Gibbes .....	1
Prof. Jeffries Wyman.....	2	<i>Concord, N. H.</i>	
<i>Cave Spring, Ga.</i>		New Hampshire Historical Society.....	2
Institution for Deaf and Dumb.....	1	<i>Cannellton, Ind.</i>	
<i>Charleston, S. C.</i>		Hon. Ballard Smith .....	1
Society Library.....	3	<i>Davenport, Iowa.</i>	
Dr. Bachman.....	1	Rt. Rev. Henry W. Lee.....	1
Dr. J. M. Geddings.....	1	David Sheldon.....	1
Prof. Francis S. Holmes.....	1	<i>Des Moines, Iowa.</i>	
Prof. John E. Holbrook.....	1	State of Iowa.....	3
Dr. C. Happoldt.....	2	<i>Detroit, Mich.</i>	
Rev. Thomas Smyth .....	1	Michigan State Agricultural Society.....	26
Elliott Society of Natural History.....	16	Penin. and Independent Medical Journal.....	4
<i>Chapel Hill, N. C.</i>		J. C. Holmes.....	1
University of North Carolina.....	1	<i>Dorchester, Mass.</i>	
<i>Charlottesville, Va.</i>		Dr. E. Jarvis.....	2
University of Virginia.....	4	<i>East Greenwich, N. Y.</i>	
<i>Chicago, Ill.</i>		Asa Fitch .....	1
Illinois University.....	1	<i>Easton, Pa.</i>	
Chicago Medical Journal.....	2	Breckenridge Clemens.....	1
Mechanics' Institute.....	3	<i>Evansville, Ind.</i>	
Col. J. D. Graham.....	6	Hermann Flügel.....	1
M. C. Herrenkind .....	1	<i>Frankfort, Ky.</i>	
<i>Chuquisaca, Bolivia.</i>		Geological Survey of Kentucky .....	5
University of Chuquisaca.....	2	<i>Gambier, Ohio.</i>	
<i>Cincinnati, Ohio.</i>		Kenyon College.....	2
American Medical Journal.....	2	<i>Georgetown, D. C.</i>	
Historical and Philos' Society of Ohio.....	2	Georgetown College.....	16
Mercantile Library.....	3		
Observatory .....	3		
Public Library of Cincinnati.....	1		
John G. Anthony.....	1		
Prof. Mitchell.....	2		
Dr. Newton .....	1		
<i>Cleveland, Ohio.</i>			
Dr. J. S. Newberry.....	2		
<i>Clinton, N. Y.</i>			
Dr. C. H. Peters.....	1		

## D—Continued.

	Number of packages.		Number of packages.
<i>Hartford, Conn.</i>		<i>Madison, Wis.</i>	
Historical Society of Connecticut.....	2	Educational Society of Wisconsin.....	1
Society of Physical Science.....	1	Hon. Henry Barnard.....	1
Young Men's Institute.....	2	A. C. Ingham.....	1
<i>Hanover, N. H.</i>		Society for Education of Blind.....	2
Dartmouth College.....	8	Wisconsin State Agricultural Society...	37
<i>Havana, Cuba.</i>		Historical Society of Wisconsin.....	7
Observ. Phys. Meteorol. de la Havana.	2	<i>Montreal, Canada.</i>	
<i>Hudson, Ohio.</i>		Natural History Society.....	1
Western Reserve Observatory.....	1	College of Montreal.....	1
<i>Indianapolis, Ind.</i>		T. Sterry Hunt.....	1
Indiana Historical Society.....	2	Dr. Kingston.....	1
Institution for Deaf and Dumb.....	1	Sir William E. Logan.....	1
<i>Iowa City, Iowa.</i>		<i>McConnellsville, Ohio.</i>	
State University.....	30	Hon. Elijah Hayward.....	1
<i>Jefferson, Mo.</i>		<i>Milledgeville, Ga.</i>	
Historical and Philosophical Society of Missouri.....	2	Oglethorpe University.....	4
<i>Lansing, Mich.</i>		Professor James Woodrow.....	1
Michigan Agricultural Society.....	1	<i>Montpelier, Vt.</i>	
<i>Lebanon, Tenn.</i>		Historical and Antiquarian Society of Vermont.....	2
James M. Safford.....	1	<i>Nantucket, Mass.</i>	
<i>Lexington, Ky.</i>		Miss Mitchell.....	2
Transylvania University.....	1	<i>Nashville, Tenn.</i>	
<i>Little Rock, Ark.</i>		University of Nashville.....	1
Governor of Arkansas.....	1	<i>Natchez, Miss.</i>	
Arkansas State Institute.....	1	Public Library.....	1
State of Arkansas.....	11	<i>Newark, N. J.</i>	
University of Arkansas.....	3	Historical Society of New Jersey.....	3
<i>Long Island, N. Y.</i>		<i>New Brunswick, N. J.</i>	
Dr. Louis Bauer.....	1	Prof. George H. Cook.....	7
<i>Louisville, Ky.</i>		<i>New Harmony, Ind.</i>	
Historical Society.....	2	Dr. D. D. Owen.....	5
Col. Long.....	1	<i>New Haven, Conn.</i>	
Prof. J. Lawrence Smith.....	1	American Journal of Science.....	20
		American Oriental Society.....	12
		W. P. Blake.....	4
		Prof. J. D. Dana.....	30

D—Continued.

	Number of packages.		Number of packages.
<i>New Haven, Conn.—Continued.</i>		<i>Oxford, Penn.</i>	
Yale College.....	11	Dr. E. Pfeiffer.....	1
George J. Brush.....	2	<i>Philadelphia, Penn.</i>	
Daniel C. Eaton.....	1	Academy of Natural Sciences.....	99
Samuel W. Johnson.....	1	American Philosophical Society.....	64
Prof. E. Loomis.....	8	Central High School.....	2
Lieut. Olmstead.....	2	Historical Society of Pennsylvania.....	3
Prof. Charles U. Shephard.....	1	Philadelphia Library Company.....	4
Prof. Silliman.....	25	W. G. Binney.....	1
Prof. W. D. Whitney.....	3	Isaac Lea.....	17
<i>New Orleans, La.</i>		Dr. John L. Leconte.....	4
New Orleans Academy of Natural Sciences.....	23	Dr. Joseph Leidy.....	19
Lyceum of Natural History.....	1	Franklin Institute.....	9
University of Louisiana.....	1	Geological Society.....	2
Dr. Bennet Dowler.....	2	Geological Survey.....	4
<i>Newport, R. I.</i>		Loganian Library.....	1
Redwood Library.....	1	North American Medical and Surgical Review.....	2
<i>Newton Centre, Mass.</i>		Wagner Free Institute.....	8
Horatio B. Hackett.....	1	T. A. Conrad.....	1
<i>New York, N. Y.</i>		Lorin Blodget.....	2
American Geographical and Statistical Society.....	40	Prof. F. A. Genth.....	1
New York Lyceum of Natural History.....	38	S. S. Haldeman.....	1
American Ethnological Society.....	8	J. P. Lesley.....	1
American Bible Society.....	1	Chester Morris.....	1
American Institute.....	8	Richard Narlan.....	1
American Agricultural Intelligencer.....	1	William Sharswood.....	7
Astor Library.....	1	H. S. Tanner.....	2
Editor of the State's Zeitung.....	1	Prof. Wagner.....	1
Farmers' and Mechanics' Intelligencer.....	1	<i>Portland, Me.</i>	
Historical Society.....	1	Neal Dow, Mayor of Portland.....	1
Mercantile Library Association.....	3	<i>Porto Cabello, Venezuela.</i>	
Norton's Literary Gazette.....	2	Franklin Litchfield, late United States consul.....	1
University Library.....	7	<i>Princeton, N. J.</i>	
Philosophical Society.....	1	College of New Jersey.....	3
Prof. Clarke.....	1	<i>Providence, R. I.</i>	
Daniel C. Eaton.....	1	Brown University.....	4
Prof. Wolcott Gibbs.....	2	Rhode Island Historical Society.....	1
Henry Grinnell.....	4	<i>Quebec, Canada.</i>	
M. Harlan.....	3	Legislative Library of Canada.....	1
Dr. John C. Jay.....	2	<i>Richmond, Va.</i>	
Dr. Charles A. Joy.....	1	Historical Society of Virginia.....	2
Charles Loosey (Consul Gen'l, Austria).....	4	Virginia State Library.....	1
Temple Prime.....	1	<i>Rochester, N. Y.</i>	
John Lothrop Motley.....	1	University Library.....	1
James Renwick.....	1		
Mr. Sullivan.....	1		
Dr. John Torrey.....	5		
Mr. Tuckerman.....	1		

## D—Continued.

	Number of packages.		Number of packages.
<i>Rock Island, Ill.</i>		<i>Springfield, Mass.</i>	
B. D. Walsh .....	1	William Tully .....	2
<i>Rio Janeiro, Brazil.</i>		<i>Toronto, C. W.</i>	
Inst. Hist. Geogr. of Brazil.....	2	Canadian Institute.....	6
Herr Rieder.....	1	Board of Agriculture, Upper Canada....	1
<i>Roxbury, Mass.</i>		Trinity College.....	2
Dr. Reinhold Sölger.....	1	Prof. Kingston.....	1
<i>Salem, Mass.</i>		<i>Tripoli.</i>	
Essex Institute .....	2	Daniel Smith McCauley, late United States consul.....	1
Prof. F. L. Russell.....	1	<i>Tuscaloosa, Ala.</i>	
<i>Santiago, Chili.</i>		University of Alabama .....	2
Institute de Santiago .....	1	<i>Utica, N. Y.</i>	
Observatory.....	6	American Journal of Insanity.....	5
University.....	10	<i>Valdivia, Chili.</i>	
Prof. Ignacio Domeyko.....	1	Dr. Eugen Von Bock.....	1
Dr. Landheeth.....	2	<i>Vandalia, Ill.</i>	
Prof. Lobeck.....	1	Historical Society of Illinois.....	1
Prof. R. A. Philippi.....	1	<i>Valparaiso, Chili.</i>	
<i>Savannah, Ga.</i>		Dr. Thomas A. Reid .....	8
Georgia Historical Society.....	2	<i>Washington, D. C.</i>	
<i>St. Paul, Minn.</i>		United States Patent Office.....	87
Historical Society of St. Paul.....	2	Ordnance Bureau.....	2
<i>San Francisco, Cal.</i>		United States Coast Survey.....	12
California Academy of Natural Sciences.	20	National Observatory.....	32
Dr. W. O. Ayres .....	1	Secretary of War .....	2
<i>St. Louis, Mo.</i>		Surgeon General.....	1
St. Louis Academy of Sciences.....	85	Lieutenant J. M. Gilliss, U. S. N.....	36
Dr. George Engelmann.....	9	William Stimpson .....	5
Dr. Wizlicenus .....	9	F. B. Meek, and Dr. F. V. Hayden.....	2
Deutsche Inst. für Bef. im Wiss. Kunst. un Gew.....	9	Congress Library.....	6
Geological Survey of Missouri, (Columbia, Mo.).....	7	His Excellency James Buchanan .....	1
St. Louis Medical and Surgical Journal.	2	Commissioner of Indian Affairs.....	1
University Library.....	2	Commissioner of Patents.....	5
E. C. Angelrodt.....	1	Secretary of State.....	1
George Bemays.....	1	Superintendent of Statistical Office.....	1
Dr. Adam Hammer.....	1	National Institute.....	3
N. Holmes.....	1	Trigonometrical Survey.....	1
Dr. Albert Koch .....	2	United States Agricultural Society.....	1
Dr. B. F. Shumard.....	10	War Department.....	1
Prof. G. C. Swallow .....	1	Colonel Abert.....	2
<i>Springfield, Ill.</i>		Prof. S. F. Baird .....	2
Prof. Esbjörn.....	1	Prof. A. D. Bache .....	46
		Major Emory.....	1



## D—Continued.

	Number of packages.		Number of packages.
<i>Washington, D. C.—Continued.</i>		<i>Waterville, Me.</i>	
Prof. Espy.....	2	Waterville College.....	2
A. Ferguson.....	3		
Hon. Peter Force.....	1	<i>West Chester, Penn.</i>	
Dr. C. Girard.....	3	W. Darlington.....	1
Captain H. J. Hartstene.....	5		
Baron de Gerolt.....	1	<i>West Point, N. Y.</i>	
Captain A. A. Humphreys.....	1	Military Academy .....	1
Prof. S. S. Hubbard.....	1	Prof. Bartlett .....	3
Prof. W. R. Johnson.....	2		
Lieutenant S. P. Lee.....	1	<i>Williamstown, Mass.</i>	
Lieutenant M. F. Maury .....	48	Observatory .....	1
George W. Riggs.....	4		
Baron Osten Sacken.....	1	<i>Worcester, Mass</i>	
Charles A. Schott.....	1	American Antiquarian Society.....	9
H. R. Schoolcraft.....	4		
J. C. G. Kennedy .....	1		
John Xantus .....	1		
Total of addresses.....		335	
Total of parcels .....		1,908	

By a comparison with the last report, it will be seen that the total number of parcels received for other parties in 1860, is about the same as in 1859. Their bulk, however, is much greater, owing to the consolidation by the agents of the Institution, and by societies, of several parcels to the same address into one package before transmission, as advised by the Institution. The average number of parcels to each address is nearly six.

## MUSEUM AND COLLECTIONS.

*Additions to the Museum and Collections.*—During the year 1860 important additions have been made to the collection of various species, chiefly North American, and serving to render it nearly complete as regards a large part of the fauna of the continent. Many new facts in regard to the geographical distribution of species over its whole extent, and their habits, have been obtained, while carefully prepared measurements, weighings, and other facts bearing on the physical constants of animals, as called for in Mr. Babbage's article in the Smithsonian Report for 1856, have been accumulated in great numbers in the labels and catalogues accompanying the specimens.

The great bulk of material received has consisted of specimens deposited by the officers in charge of Government expeditions pursuant to the act of Congress in relation to the subject. Next to these, of collections made in equally or still more unexplored regions of North America at the instance, or through the instrumentality, of this Institution, and involving not merely the addition of specimens, but accom-

panied by most important results in physical science. Comparatively nothing has been received from the more known portions of the United States; the transmission of fishes, reptiles, &c., having almost entirely ceased. This is due to the fact that no effort has been made to secure such specimens, on account of the comparative completeness of the series, and the expense of enlarging them. There is already a large accumulation of such material in the Institution, which, however, the systematic arrangement for distribution of labeled duplicates now in progress will speedily and greatly deplete.

The only departments of natural history to which additions have been made from all parts of the United States, have been those of conchology, entomology, and oölogy. Circulars were issued in 1859 and 1860 inviting contributions of material towards a series of works on these subjects which the Institution had in contemplation, to be written by the most competent authorities. The invitation has been generally responded to by the transmission of many parcels, (many of them containing types of rare species.) These have been placed in the hands of the collaborators of the Institution as received, and have proved of great importance.

The following is a detailed statement of the most important collections received in 1860:

FROM EXPLORATIONS UNDER THE WAR DEPARTMENT.

*Construction of Wagon Road from Walla-Walla to Fort Benton, under Lieutenant John Mullan, U. S. A.*—The work of this expedition was carried out to Fort Benton during the past season, so as to render the road passable throughout. Large collections, chiefly of fossils, birds, and plants, were made by Mr. John Pearsall and Mr. Hildreth, attachés of the party.

*Exploration of the Upper Missouri and Yellowstone, under Captain W. F. Reynolds, U. S. A.*—After spending the winter at Deer Creek, on the Platte, west of Fort Laramie, explorations were resumed by the expedition in May. Dividing into two parties—one commanded by Captain Reynolds, and accompanied by Dr. Hayden; the other by Lieutenant Maynadier, with Mr. George H. Trook as collector—they proceeded to explore the Wind River mountains, and other localities between the Platte and the Upper Missouri, as far north as Fort Benton. Finishing their labors during the summer, both parties united at Fort Randall, and returned to Washington in November.

Many important collections were made by the expedition, of fossils, plants, and zoölogical specimens. In the Wind River mountains especially, specimens were obtained of great interest, among them what is believed to be a new species of Alpine hare.

*Movement of United States Troops to Oregon, via Fort Benton, under Major G. H. Blake, U. S. A.*—This party was accompanied by Dr. J. G. Cooper as one of its medical officers, who made some valuable collections of specimens, serving to extend the information respecting the species inhabiting Oregon and Washington, as recorded in the re-

port on the subject made to Governor Stevens by Dr. Cooper and Dr. Suckley.

*Artesian Well Expedition, under Captain J. Pope, U. S. A.*—The remainder of the collections of this party, consisting principally of specimens in alcohol, have been received from Captain Pope.

FROM EXPLORATIONS UNDER THE STATE DEPARTMENT.

*Survey of the Northwestern Boundary, Archibald Campbell, Commissioner.*—This commission nearly completed its work during the year, and is now on its return home. Large collections in geology and natural history have been made by Dr. Kennerly and Mr. George Gibbs, in continuation and completion of those previously reported on.

FROM EXPLORATIONS UNDER THE INTERIOR DEPARTMENT.

*Survey of the Northern Boundary of Texas, J. H. Clark, Commissioner.*—In addition to other specimens, a very complete collection of nests and eggs of birds was made during the past spring along the line of this survey by Mr. Charles S. McCarthy, including several species previously unknown to science.

FROM EXPLORATIONS UNDER THE NAVY DEPARTMENT.

*Exploration of the Parana and its tributaries, under Capt. T. J. Page, United States Navy.*—This expedition completed its important work during the year 1860, and has returned to the United States. In addition to its geographical and hydrographical labors, much attention was paid to natural history; and among the large collections brought home are many new and rare species. The birds of the country visited are especially interesting; the series, prepared chiefly by Mr. Christopher Wood, being perhaps the largest ever made in that region.

FROM EXPLORATIONS MORE SPECIALLY CONNECTED WITH THE SMITHSONIAN INSTITUTION.

*Exploration of Cape St. Lucas, by Mr. John Xantus.*—In the last report reference was made to an exploration of Cape St. Lucas, the southern extremity of the Peninsula of Lower California, by Mr. John Xantus, tidal observer of the United States Coast Survey. This exploration, so far as the natural history results are concerned, may be considered as completed; as, although many isolated species may yet remain uncollected, the general peculiarities of its fauna and flora are now well ascertained. Besides the addition of a larger number of new animals to our fauna than has been made by one person in any single region of North America before, Mr. Xantus has shown that the most interesting relationship exists between the land species of the Cape and those of the region of the Gila, Upper Rio Grande, and the southern Rocky Mountains. On the other hand, very few of the characteristic species of the coast of Upper California occur at the Cape; while, as far as observed, the same may be said of the strictly Mexican types.

The entire Peninsula thus proves to be as specially related to North America in its land fauna as is Florida, although the number of peculiar species is much greater.

The marine fauna of Cape St. Lucas proves to be quite Panamic in its general features—much more so than the opposite coast of Mexico.

It is out of my power, at present, to present a statement of the number of species collected by Mr. Xantus during his residence (when last heard from) of about eighteen months. There are, however, known to be about twenty new birds, as many reptiles, large numbers of fishes, crustaceans, and other groups in proportion. The collection of shells is much larger than any ever made on the west coast, with the exception of that by Mr. Reigen, forming the basis of the report on Mazatlan shells, by Mr. Carpenter, and is superior to any other in the extent of the species preserved entire in alcohol. The general results form a fitting continuation of the labors of Mr. Xantus at Fort Tejon, referred to in preceding reports; and the whole will form an extraordinary monument of the ability of a single intelligent and accomplished collector to nearly exhaust the natural history of an extensive region, under difficulties sometimes apparently almost insuperable.

To the Superintendent of the Coast Survey, natural science must ever acknowledge a great indebtedness for placing Mr. Xantus in a position to make his explorations, by authorizing and establishing a self-registering tide-gauge station at the Cape, and placing Mr. Xantus in charge. All his collections were made in the intervals of his duty as observer upon the tides, meteorology, &c., for the Coast Survey.

*Explorations in the Gulf of California, by Capt. Stone.*—Capt. Stone, in charge of the survey of Sonora, caused numerous collections to be made in the northern part of the Gulf, chiefly opposite Guayamas. Of these a portion, consisting principally of shells, have been received during the year, and prove to be of much interest, not only in themselves, but as completing the history of Cape St. Lucas and Mazatlan species.

*Exploration of the vicinity of Fort Crook, by Mr. John Feilner.*—Mr. Feilner, sergeant of company F., first dragoons, stationed at Fort Crook, under command of Captain John Adams, United States Army, has considerably extended the collections referred to in the last report. In May last, by permission of Captain Adams, he visited the lake region to the north of Fort Crook, with one companion, with the view of pursuing his researches among the breeding places of the water birds of California. After meeting with much success, he was attacked by hostile Indians, but succeeded in fighting his way through, killing several of his assailants, and, unfortunately, with the loss of a considerable proportion of his collections. His gallantry, and that of his companion, Private Guise, have been made the subject of especial commendation in a general order from the War Department.

Dr. Vollum, United States Army, surgeon of Fort Crook, has also made various collections for the Institution; and Hospital Steward Par-

kinson has transmitted others not yet received; so that this fort bids fair to be as well marked for an almost perfect knowledge of its natural history as Fort Tejon through the labors of Mr. Xantus. A comparison of collections from these two points in the same range of mountains, dividing the Pacific and middle faunas, and about 500 miles apart, has proved of scientific interest in determining the geographical distribution and variation of the species of California animals, many of the facts elicited being quite unexpected.

*Exploration of other points on the West Coast.*—Dr. C. A. Canfield, of Monterey, has gathered additional materials for illustrating the natural history of his vicinity. Rev. Jos. Rowell and Dr. W. O. Ayres have furnished important collections of shells for Mr. Carpenter's use, in his proposed elaboration of the conchology of western America. Mr. J. G. Swan, of Washington Territory, has also contributed largely to the same object. Specimens of birds and eggs have been received from Mr. Hepburn, of San Francisco, and Mr. Ferdinand Gruber; and of Californian coniferae, from Mr. Wm. Murray.

*Exploration of the Hudson's Bay territory, by Mr. Robt. Kennicott.*—In the last report reference was made to the exploration of the Hudson's Bay country by Mr. Robt. Kennicott. Since that report was written, advices have been received from him up to July, 1860. He had reached Fort Simpson in September, and after a short excursion up the Liard river to Fort Liard, in the Rocky Mountains, returned to Simpson, where he spent the winter as the guest of Mr. B. R. Ross, the gentleman in charge of the Mackenzie River district. In the spring he went to Great Slave Lake for the purpose of collecting eggs; making Fort Resolution his headquarters, and meeting with great success.

For a most generous coöperation of the Hudson's Bay Company, through Sir George Simpson, and its officers in England and America, the Institution is under the greatest obligations. Every possible facility has been furnished to Mr. Kennicott, not only in permission to visit the different posts, but in the way of free transportation of himself and his collections, quarters at the posts, &c. Wherever he has gone he has found an appreciation of his mission and a readiness to assist, gratifying in the highest degree. Nearly all the gentlemen in charge of different posts have undertaken to make observations in meteorology for the Institution, (for which purpose Mr. Kennicott carried with him blank registers, thermometers, &c.,) as well as collections of such objects of natural history as he might not succeed in securing himself.

The gentlemen to whom Mr. Kennicott expresses his indebtedness most particularly, after Mr. Ross, are Mr. L. Clarke, Mr. J. Reid, Mr. A. McKenzie, Mr. MacFarlane, and Mr. Hardisty.

To Mr. B. R. Ross, chief trader, in charge of the Mackenzie River district, the Institution is under great obligations, not only for protection and assistance to Mr. Kennicott, which his official position so well enabled him to furnish, but for a special contribution of his own. In coöperation with the officers of the posts in his district, he has undertaken and already, to some extent, realized a special exploration of his district, entirely independent of that of Mr. Kennicott. Full observations upon the climatology, periodical phenomena, and other

features of the country, will be made, with collections illustrating its natural history, ethnology, &c., and transmitted to the Institution. A large amount of material has already been received from him and his coadjutors in the way of meteorology and natural history. Among the more important animals are skins of the Rocky Mountain goat, Arctic reindeer, Barren Ground bear, Hare-Indian dog, &c.; skeletons of goat, reindeer, wolverene, skins of various fishes, as *Thymallus*, *Salmo Mackenzii*, &c.; Esquimaux and Indian curiosities, with many other objects of equal interest.

Mr. W. Mactavish, chief factor, resident at Fort Garry, has laid the Institution under special obligations by his assistance in the transmission of supplies to and reception of collections from Mr. Kennicott, as well as himself procuring specimens from different points and forwarding to Washington.

Mr. Kennicott intended to return to Fort Simpson in August, and to proceed down the Mackenzie to Fort Good Hope; thence across the Rocky Mountains to Fort Yukon, on the Yukon river, a post in the interior of Russian-America. There, in a region almost entirely unknown, not merely in its natural history, but its very geography, he expects to remain until next summer, then to proceed to some other desirable center of operations.

It will be remembered that while the chief expenses of Mr. Kennicott's operations are sustained by this Institution, very important assistance has been received from the University of Michigan, the Chicago Audubon Club, and the Chicago Academy of Natural Sciences, together with several gentlemen interested in natural history. Without the facilities furnished by the Hudson's Bay Company and its officers, however, the enterprise, in its present extent, would be entirely impracticable.

Mr. George Barnston, of Michipicoten, Lake Superior, to whom Mr. Kennicott was much indebted for the favorable direction of his operations at the outset, has furnished many desirable additions to the collections of the Institution from the north shore of Lake Superior. Chief among these may be mentioned a skin of the reindeer in superb condition, and now mounted in the museum; also, a nearly complete skeleton of the same animal.

*Exploration of James' Bay by Mr. C. Drexler.*—Mr. C. Drexler visited James' Bay, the southern extremity of Hudson's Bay, in May last, and remained until September. He reached Moose Factory the end of May, and after a few days, proceeded in a canoe, with some Indians, as far along the east coast as Fort George, where he remained some time. He was chiefly engaged in the collection of eggs of birds, though all other departments of natural history received his attention.

As in the case of Mr. Kennicott, the aid of the Hudson's Bay Company has been indispensable to the success of Mr. Drexler's enterprise. The facilities ordered by Sir George Simpson, and carried out by Mr. John McKenzie, at Moose Factory, with the coöperation of the gentlemen at the posts visited, enabled him, with the small means at his command, to accomplish results of great interest and magnitude. The collections made by Mr. Drexler were also taken from Moose Factory

to London, free of expense, in the ship belonging to the Hudson's Bay Company, and then transmitted to this country.

Beside the aid furnished by the Institution, it is proper to state that the chief portion of the funds used in meeting Mr. Drexler's expenses were supplied by Dr. Henry Bryant, of Boston.

*Explorations on the Labrador Coast.*—Mr. Elliot Coues, of Washington, visited the Labrador coast last spring, in the vessel chartered by Mr. John W. Dodge, and spent several months there, going as far north as Rigolette. His collection consisted chiefly of birds and eggs, of which several rare species were procured.

During the United States Coast Survey expedition to Cape Chadleigh, on the steamer Bibb, for the purpose of observing the total eclipse of the sun of July 18, a number of specimens were obtained by Mr. W. A. Henry, one of the party.

*Explorations in the Gulf of St. Lawrence, by Dr. Henry Bryant.*—Dr. Bryant chartered a vessel at Gaspé, and in it spent several months visiting various points in the Gulf and on the adjacent coasts. His researches were principally in reference to the breeding of the water birds, and important facts in regard to this point were collected by him. Full series of his specimens have been presented by him to the Institution.

*Exploration of the Coast of Labrador and of Greenland, by Williams College.*—This expedition, composed of students of Williams College, under the direction of Prof. Chadbourne, spent several months along the above-mentioned coasts, making interesting collections of natural history, selections from which have generously been supplied to the Smithsonian Institution.

*Explorations on the Southern Coast of the United States.*—Interesting collections from the vicinity of Micanopy have been received from Dr. Bean, and others from Dr. Bryant. Dr. J. B. Holder, now medical officer at Fort Jefferson, Tortugas, has made valuable contributions, chiefly of birds and eggs, serving to extend and complete those of Captains Wright and Woodbury, and Dr. Whitehurst. Specimens of several rare birds were also received from Captain Woodbury. From Mr. Maslin and Mr. Keyser, tidal observers of the United States Coast Survey, collections were also received, made in the vicinity of Charlotte harbor and Cedar Keys. Sergeant Alexander, at Fort Macon, North Carolina, has also transmitted numerous specimens.

Dr. Stimpson and Mr. Gill spent some weeks in the vicinity of Beaufort, North Carolina, during the past spring, and occupied themselves principally in an investigation of the marine fauna of that region. Many species of shells were collected, some of very remarkable character, as being previously known only as fossils of our coast deposits. Specimens of an *Amphioxus* were obtained, not recorded before as belonging to the American fauna.

*Explorations in the interior of the United States.*—Reference has already been made to the results of various Government expeditions in the Rocky Mountains and elsewhere. In addition to these, valuable

collections of animals from the vicinity of Cantonment Burgwyn, New Mexico, have been received from Dr. Anderson, United States Army, in completion of previous transmissions. These are of especial interest as showing an arctic type of the fauna in the high mountain regions of New Mexico, previously quite unexpected. The pine grosbeak, evening grosbeak, the crossbill, and similar species, appear to be constant residents. Dr. Anderson also collected many specimens in his march eastward through Texas; among them, the first skin of *Hypotrionchis femoralis* received by the Institution.

Dr. Irwin, United States Army, has also furnished important contributions from the vicinity of Fort Buchanan, in Arizona, embracing new species of reptiles and insects, and many rare birds and eggs.

An interesting collection of birds, plants, and other specimens of natural history was made in the vicinity of Fort Stockton, Texas, by Mr. Patrick Duffy, and is of value as illustrating the natural history of the high plains. Collections were also made in western Texas by Mr. F. Kellogg and Mr. F. S. Wade.

Important collections of nests and eggs of birds were made for the Institution by Dr. Hay, at Racine, Dr. Hammond, in Indiana, Mr. Tolman, at Winnebago, and others.

*From Explorations in other parts of the World.*—Captain Dow, of the Panama railroad service, has transmitted several collections during the year. The most important of these consist of shells, embracing several new rare species, and considered by Mr. Carpenter as of much value in determining the fauna of the west coast. A new species of *Anableps*, and other fishes, new genera and species of crustacea, &c., are also among his collections.

Dr. C. Sartorius, of Vera Cruz, has supplied desirable specimens of Mexican animals, illustrating the distribution of North American species. Mr. I. A. Nieto has contributed specimens of woods of many species of Mexican trees, and a series of coleoptera. Shells of the coast of Chili have been received from Mr. Flint, of Caldera; a very full collection of eggs of birds of Chili, prepared by Mr. F. Germain, from Don Jacinto R. Peña, of Santiago, &c. A series of birds of Guatemala, received from Mr. Osbert Salvin, will be of much service to American ornithologists, as embracing many species not otherwise accessible in this country to them.

Valuable specimens of birds and eggs of Greenland, and of northern Europe, have been received from the Royal Museum and the University Museum of Copenhagen.

Further indications of more or less important additions to our knowledge of the natural history of particular regions will be found in the list of donations subsequently presented.

#### WORK DONE IN CONNECTION WITH THE COLLECTIONS.

In accordance with your wish, the preliminaries to a distribution of the duplicates of the collection in the museum have been pushed forward as fast as possible during the year. The assorting of the large mass of shells belonging to the Institution, by Mr. Carpenter,



has progressed to such an extent that all the duplicate specimens of each kind belonging to the general Indo-Pacific fauna are now in separate boxes, which are arranged systematically and numbered, to correspond with the numbers of a printed list, so that sets can be picked out and distributed with but little trouble. In the labor of assorting and naming the collection, he has had the coöperation of Mr. Isaac Lea and Dr. E. Foreman, with the *Unionidae*; of Mr. Lea, with the water breathing univalves; of Mr. Binney, with the air breathing univalves; of Mr. Stimpson, with the east coast species; of Mr. Temple Prime, with the *Cycladidae*; and of Dr. A. A. Gould, with the species generally. All the type shells of the exploring expedition, and many of those of the North Pacific expedition, with large numbers of other shells, have been mounted by Mr. Carpenter, or under his direction, upon many thousand glass tablets, as referred to in the last report, page 70.

The systematic arrangement and determination of the other branches of natural history, their careful catalogue and operations necessary to the separation of duplicates and their distribution so as to be of most use, in nearly all the different departments of natural history has been carried forward very laboriously. In this, I have been much aided by the voluntary services of several gentlemen, especially by Mr. Elliot Coues and Mr. W. Prentice. The following table will show the amount of work of the kind done :

*Table exhibiting the entries in the record books of the Smithsonian collection in 1860, in continuation of previous years.*

	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.
Skeletons and skulls...	911	1,074	1,190	1,275	2,050	3,060	3,340	3,413	3,650	4,350
Mammals.....		114	198	351	1,200	2,046	3,200	3,226	3,750	4,575
Birds.....				4,353	4,425	5,855	8,766	11,390	15,913	20,875
Reptiles.....						106	239	4,370	4,616	4,683
Fishes.....						155	613	1,136	1,740	2,975
Eggs of birds.....								1,032	2,525	4,425
Crustacea.....								939	939	979
Mollusks.....									2,000	8,832
Radiates.....									1,100	1,308
Fossils.....									171	705
Minerals.....									793	1,132
Ethnological specimens.....										550
Total.....	911	1,188	1,388	5,979	7,675	11,222	16,158	25,506	37,197	55,389

The actual number of entries during the year amounts to 18,192, or not far from twice as many as in 1859. The aggregate of 55,389 is, however, far from representing the entire number of specimens already recorded, some numbers covering tens and often hundreds each. Thus, of fishes there are at least 15,000 specimens recorded, and nearly as many of reptiles. Under the 4,425 entries of eggs, there are included 17,182 eggs and 1,294 nests, and other classes are in proportion.

With but trivial exceptions, the osteological specimens—the eggs and the mammals, birds and reptiles—are catalogued, though not all determined. The greater portion of the fishes, and of most of the other classes, excepting perhaps the shells, still remain to be done.

With the view of carrying out the arrangement between yourself and Drs. Torrey and Gray, in reference to the selection of a single series of all the botanical collections made and deposited by the various government exploring expeditions and received from other sources, the entire herbarium has been placed in their hands for the purpose.

Nearly all the mammals, the North American birds, and the exotic water birds exhibited in the museum, have been labeled with both scientific and vernacular names as far as these could be ascertained. The remaining specimens will be similarly treated as fast as they can be properly identified. The entire osteological collection has been placed on exhibition, as also the geological collections of the Pacific railroad and some other Government parties, in the northeast and southeast galleries of the museum hall, first opened to the public during the year.

A large number of skins of North American mammals and birds, not previously exhibited, have been mounted and placed in the cases. All the old stands of mounted specimens have been replaced by new ones, and the entire series is believed to be in a good condition, although much remains to be done for its perfection by adding deficiencies of North American species, and replacing old, faded, badly-prepared, and otherwise discreditable specimens, by fresher and better ones.

Of the collections mentioned in the last report as in the hands of collaborators residing out of Washington, the *Ophiuridae* have been returned, labeled, and identified by Mr. Theodore Lyman, of Brooklyn. Many new species were found among the Smithsonian specimens, which have been characterized in the proceedings of the Boston Society of Natural History, and will be described in detail in a monograph. The *Echini* of the North Pacific expedition have been worked up and returned by Mr. Barnard, and much progress made in the determination of the *Crustacea* and sea glars of the same expedition by Mr. Stimpson, and of its fishes by Mr. Gill. Mr. Cassin has completed his investigations upon the birds of Lieutenant Michler's expedition to the Atrato, and of the North Pacific expedition, and returned the specimens. The herpetology of the North Pacific expedition, originally prepared by Dr. Hallowell, has been revised and brought up to date by Mr. Cope, who has also made some important examinations of serpents in the collection of the Institution.

No reports of return of specimens have been made during the year by the gentlemen mentioned in the last report as having Smithsonian material in charge, as follows: *Turtles* by Professor Agassiz, *Etheostomoids* by Mr. F. W. Putnam, *Siluridae* by Dr. Wheatland, all of the Cambridge Zoölogical museum; fossil vertebrata collected by Dr. Hayden during the expedition of Lieutenant Warren, in the hands of Dr. Joseph Leidy, of the Philadelphia Academy. Of other series not yet mentioned in the present report, the coleoptera are in the hands of Dr. Le Conte, the neuroptera of Dr. Hagen, the diptera of Dr. Loew, the lepidoptera of Dr. Morris and Mr. Edwards, the water breathing univalves of North America of Mr. W. G. Binney, the west coast and exploring expedition shells of Mr. P. P. Carpenter. The birds of Captain Page's Paraguay expedition and of Lieutenant Herndon's

Amazon exploration are in course of examination by Mr. Cassin. Mr. Meek has completed the labeling of the fossils of Captain Simpson's expedition, collected by Dr. Engelmann.

Although so much labor has been expended in the examinations and investigation of the Smithsonian collection, a vast amount yet remains to be done before it can be considered as entirely exhausted of its novelties. Probably no collection of its size in the world contains so many types of published species, and so many yet new ones yet undescribed. This is especially the case in regard to North America, as well as to many other parts of the world. Much desire is therefore manifested by persons, about entering upon the preparation of monographs to secure the privilege of using Smithsonian specimens.

#### PRESENT CONDITION OF THE MUSEUM.

In the report for 1858 will be found an account of the most important collections forming the bulk of the museum of the Smithsonian Institution. It was continued in the report of 1859, and I beg leave to present at the end of the report a list of all the donations received in 1860.\*

Numerous specimens were received during the year from expeditions referred to in the last report, as from Captain Simpson, Captain Reynolds, Lieutenant Mullan, Mr. John Xantus, Mr. John Feilner, Robert Kennicott, Dr. Bean, and others.

These additions to the museum have resulted in the filling up of many important gaps, and in replacing many defective specimens by better ones. By the arrangements in progress for distribution of duplicates, and the removal from the building of what is neither worth

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\* For convenience of reference, I continue the enumeration of collections, made chiefly during certain explorations, from page 71 of the report for 1859:

73. Collections made during the march of troops to Oregon, *via* Fort Benton, under Major G. H. Blake, by Dr. Cooper.

74. Collections made in the Gulf of California, by the party of Captain C. P. Stone.

75. Collections made on the coast of California, by Dr. C. S. Canfield.

76. Collections made in the Mackenzie river district, by Mr. B. R. Ross, with the coöperation of other officers of the Hudson Bay Company.

77. Collections made on the north shore of Lake Superior, by Mr. George Barnston.

78. Collections made at Moose Factory, by Mr. J. McKenzie.

79. Collections made in James bay, by Mr. C. Drexler.

80. Collections made on the coast of Labrador, by Mr. Elliot Coues.

81. Collections made in Greenland and Labrador, by the Williams College Lyceum of Natural History.

82. Collections made on the coast of North Carolina, by Dr. Stimpson and Mr. Gill.

83. Collections made at Cantonment Burgwyn, N. M., on the Pecos, by Dr. W. W. Anderson.

84. Collections made on the Texas boundary survey, by Mr. J. H. Clark.

85. Collections made in Puget Sound, by J. G. Swan, Esq.

86. Collections made at the Tortugas, by Dr. J. B. Holder.

87. Collections made in Cuba, by Mr. Charles Wright.

88. Collections made in Minnesota, by Mr. J. M. Woodward.

89. Collections made in New Mexico, by Patrick Duffy, Esq.

90. Collections made on the Labrador Eclipse Expedition, by W. A. Henry.

91. Collections made on the Atlantic coast of the United States, by Lieutenant J. D. Kurtz

92. Collections made in Chili, by Mr. F. Germain, through Don J. R. Peña.

93. Collections from Sable Island, by P. S. Dodd, Esq.

94. Collections from Nova Scotia, by J. R. Willis and W. G. Winton.

keeping nor giving away, it is confidently believed that instead of an unmanageable accumulation of material in the store-rooms its bulk will be reduced to at least one fourth, or more, of the present amount.

In accordance with the policy adopted by you, the efforts of the Institution have been directed mainly to the completion of its series of specimens illustrating the natural history of North America. At the present time it is believed, upon the whole, to have accomplished this aim to an extent greater than any other museum in the world. As far as regards mammals and their skulls and skeletons, birds and their eggs, reptiles, fishes, shells, crustaceans, and invertebrates generally, except certain orders of insects, (vertebrate fossils, and plants,) from the regions west of the Mississippi; it is probably not exceeded by any museum in the number of species and extent of the series, few additions remaining to be made to the list. At the same time, as successive groups are elaborated and labeled, and the duplicates distributed, the bulk of the whole becomes less and less, so that it is quite reasonable to assume that the present number of specimens will be reduced in a few years to less than half their present amount.

In addition to its American collection, derived from all the different sources, and including specimens from adjacent regions, necessary properly to illustrate it, the bulk of the Smithsonian museum consists of materials gathered by various Government expeditions in different parts of the world, and deposited here in compliance with the act of Congress. Other than as derived from this source, the exotic collections not relating to American natural history, are very small in amount, although usually of much interest from embracing numbers of new species. Among the exotic collections, the series of South American birds is believed to be among the first extant, while that of crustacea, annalids, corals, and certain families of radiata and mollusca, generally, are perhaps surpassed by very few.

As distributions of duplicates for the exotic collections are made, it is believed that the mass at present within the building will be so much reduced that the present accommodations will always be found ample for whatever may hereafter be added, as long as the present scope of the collections is adhered to. Of course, should Congress at any future time authorize an extension of the plan, the addition of exotic mounted mammals, birds, &c., would require much more space, and must be provided for by additional accommodations; these, however, would otherwise not be needed.

The great value of the museum of the Institution at the present time consists in its being the depository of so many type specimens, or those upon which the first description of species has been established. These constitute the great attraction to the scientific investigators, as, however carefully prepared the published description or figures of any species may be, there is almost always some doubtful point to be settled alone by an examination of the types. For this reason these are always guarded with jealous care, and considered of much more value than new and undescribed materials.

There are few collections embracing more original type specimens, or specimens relating to a large number of important works, than that of the Smithsonian Institution. Besides the reports of the United

States exploring expeditions of the Pacific railroad and Mexican boundary surveys, and of many other Government works, few monographs have been prepared in the United States for some years past without deriving many, or even most, of their novelties from the Smithsonian museum. The proceedings and transactions of most of the scientific journals of the country contain frequent and constant reference to its materials as the types. By the distribution of duplicates of these, therefore, and their judicious deposit at proper places in different parts of the world, a vast amount of good may be done, and the reputation of the Institution greatly enhanced.

## LIST OF DONATIONS TO THE MUSEUM DURING 1860.

- Abel, J. Ralls.*—Seventeen-year locust, Albemarle, Va.  
*Alexander, Sergeant W., U. S. A.*—Nests and eggs from Fort Macon, near Beaufort, N. C.  
*Allen, W. T.*—Birds, nests, and eggs from Rippon, Va.  
*Ambrose, Rev. J.*—Eggs of birds from Green Island, N. S.  
*Anderson, Chas. L.*—Earths and minerals from Red River country.  
*Anderson, Dr. W. W.*—Birds, eggs, and fossils from Pecos river and the Rocky Mountains.  
*Anthon, Henry, Jr.*—Fourteen specimens of native timber from the Island of Borneo.  
*Anthony, J. G.*—Collection of melanian shells; four species of *gyrotoma* from Ohio.  
*Angus, Jas.*—Seventeen-year locust.  
*Army, Wm. M. F.*—Insects in alcohol from Kansas.  
*Ayres, Dr. W. O.*—Shells, skulls of seals, and cetaceans (deposited) from California coast.  
*Baker, Chas. L.*—Tusk of boar from Washington.  
*Barnston, Geo.*—Skin and skeleton of caribou, nests and eggs of birds, and specimens in alcohol, from Lake Superior.  
*Beadle, D. W.*—Eggs of birds and alcoholic specimens from Canada.  
*Bean, Dr. J. B.*—Nests, eggs, and reptiles from Micanopy, Fla.  
*Beesley, Thos.*—Birds' eggs from New Jersey.  
*Benson, President.*—Lignite coal from Cape Palmas.  
*Bickmore, A. S.*—Nests and eggs from Hanover, N. H.  
*Bishop, N. H.*—Nests and eggs of birds and living Pine snakes from New Jersey.  
*Blakiston, Capt. T., R. A.*—Birds and eggs from Saskatchewan Plains.  
*Blossom, W. W.*—Petritified wood from Prince William county, Va.  
*Boardman, G. A.*—Five skins of *Pinicola canadensis* and eggs of birds from New Brunswick.  
*Bode, J. L.*—Mounted *Larus marinus* from New York harbor.  
*Bowman, Capt. A. W.*—Birds from Fort Massachusetts, N. H.  
*Brackett, Geo. E.*—Insects and skins of birds from Maine.  
*Bradford, Geo.*—Collections of zoölogical specimens from Cuba, made by C. Wright.  
*Brendel, Dr. F.*—Nests and eggs from Peoria, Ill.  
*Brewer, Dr.*—Skin of *Turdus fuscescens*.

- Bridger, J. L.*—Two boxes eggs, nests, &c., from Tarboro, N. C.
- Brooks, Capt. J. M., U. S. N.*—Specimen of *Hyalonema mirabilis* from Japan.
- Bryant, Dr. H.*—Nests, eggs, and skins of birds from Labrador; Sternum of *Tachypetes aquila*, Bahamas.
- Boyling, Capt.*—Birds from Washington Territory.
- Buckland, Rev. Mr.*—Shells from Sing Sing.
- California Academy of Natural Sciences.*—Shells from California.
- Campbell, A., Com. N. W. Boundary Survey.*—Skins of bear and goat, alcoholic and other specimens, collected by Dr. Kennerly and Mr. Geo. Gibbs.
- Campbell, Mr. R., per B. R. Ross.*—Skins of marmot from Athabaska Lake, H. B. T.
- Canseco, Don Valero, through J. Xantus.*—Fossil shells, &c., from Cape St. Lucas.
- Carleton, Major J. S., U. S. A.*—Collections of natural history from near Fort Tejon, California.
- Carpenter, P. P.*—Sets of Mazatlan shells.
- Catley, H.*—Birds' nests from Oregon.
- Ceseña, Donna Rosaria, through J. Xantus.*—Nests and eggs from Cape St. Lucas.
- Cassin, J.*—Skin of *Cyanocorax coronatus* from Mexico.
- Chicago Academy of Sciences and Agricultural Department, University of Chicago.*—Eggs, nests, and skins of birds from Minnesota.
- Clark, Dr.*—Auriferous sand from Laramie Hills; gold from Cherry Creek.
- Clark, Dr. John A.*—Birds, nests, and eggs, and skin of diodon from Texas.
- Clark, J. H., Texas Boundary Survey.*—Nests, eggs, and skins of birds from Arkansas, and the line of Texas Boundary Survey, collected chiefly by C. S. McCarthy.
- Clark, Wm. P.*—Eggs from Medina, Ohio.
- Clarke, L., through R. Kennicott.*—Skins of birds, eggs, &c., from Great Slave Lake, H. B. T.
- Clapp, Mr.*—Skins of birds from Florida.
- Clary, Capt.*—Ammonite from Benicia.
- Cleveland, J. T.*—Dried hippocampus, or sea horse, from Florida.
- Collier, D. C.*—Centipede and skin of *Neotoma cinerea* from Denver City, Jefferson Territory.
- Conradsen, R.*—Skins and eggs of European and Greenland birds.
- Cooper, Dr.*—Nest and egg of *Trochilus evelynae* from Nassau, N. P.
- Copenhagen Royal Museum.*—Skins and eggs of birds from Greenland and Northern Europe.
- Copenhagen University Museum.*—Skins and eggs of birds from Greenland, star fishes, &c.
- Corston, Wm.*—Eggs of snipe, &c., from Big River, H. B. T.
- Couper, Wm.*—Nests and eggs, skin of *Nyctale richardsonii*, and other birds from near Quebec.
- Coues, Elliott.*—Skins and eggs of birds and alcoholic specimens from the coast of Labrador.
- Crawford, Dr. S. W., U. S. A.*—Set of elk horns from Fort Laramie.

- Crossoman, A. J.*—Piece of root from Roger Williams tree.
- Curtis, M. A.*—Skin of mole from Hillsboro', N. C.
- Davis, C. P.*—Mounted head of female deer, with horns; also rare eggs of American and European birds.
- Davis, H.*—Nests and eggs from Iowa.
- Dawson, Prof. J. W.*—Pleistocene fossils from Canada.
- DeLeon, Dr., U. S. A.*—Silver ores from Heintzelman vein, Cerro Colorado mine, Tubac, N. M.
- DeSaussure, H.*—Skins of mammals from Labrador and Mexico.
- Diehl, J. S.*—Minerals from California.
- Dimmick, C.*—Insects from Brockport, N. Y.
- Dodd, P. N.*—Skull of walrus, skins of seals, eggs of birds, shells, &c., from Sable Island, N. S.
- Dodge, John W.*—Skin of guillemot from Labrador.
- Dodero, Donnas Juana and Pachita, through J. Xantus.*—Nests, eggs of birds, and insects from Cape St. Lucas.
- Dow, Capt. J. M.*—Collections in alcohol from Central America.
- Drexler, C.*—Collections of natural history from Hudson's Bay.
- Drouet, Mad. Helene.*—Skins and eggs of rare European and American birds; prepared skins of carp.
- Duffy, Patrick.*—Zoölogical collections from Fort Stockton, Texas.
- Dunlop, J. V., through B. R. Ross.*—Skin of marmot and skins of birds from Fort Halkett.
- Emery, Chas. A.*—Package of small shells from Stratham, N. H.; microscopic earths from New Hampshire.
- Etheridge, A. H.*—Black squirrel from Tabasco, Mexico.
- Ferrill, F.*—Eggs from Savannah.
- Feilner, John.*—Birds, mammals, nests, eggs, &c., from California.
- Fisher, Dr.*—Eggs of owl and shells from Sing Sing.
- Fitch, F.*—See *Stone*.
- Fint, C. L.*—Shells from Chili.
- Gabb, W. M.*—Package of fossils.
- Garnet, B.*—Duck's eggs, with colored epidermis, from Fairfax Co., Va.
- Garrison, O. E.*—Skins of ducks, eggs, and plants from Minnesota.
- Garton, John.*—Fish from Abitibi.
- Gerhardt, A.*—Shells, insects, eggs of birds, &c., Georgia.
- Gibbs*—See *Campbell*.
- Gill, Th.*—Marine animals from Newfoundland, the West Indies, and the coast of North Carolina.
- Gilliss, J. R.*—Shells and fossils from Payta, Panama, and Aspinwall; also living grasshopper from Panama.
- Gladmon, Mr.*—Skins of mice from Rupert House, Hudson's Bay Territory.
- Glasco, J. M.*—Snakes from Gilmer, Texas.
- Goodbow, Captain.*—Skin of a hawk from White river.
- Goodwin, E. M.*—Can of fishes from N. Montpelier, Vermont.
- Goss, B. F.*—Nests, eggs, shells, &c., Kansas.
- Gornley, James.*—Mineralogical specimens from Pike's Peak.
- Graeff, Ed. L.*—Lepidoptera from New York.
- Grayson, A. J.*—Scalp of Curassow, and contents of its stomach, (nails, coins, gravel, &c.,) Mexico.

- Griu, Donna Juana*, through *J. Xantus*.—Coleoptera from Cape St. Lucas.
- Gruber, F.*—Skins and eggs of birds from California.
- Guest, W. A.*—Jar, with sturgeon, from Ogdensburg, N. Y.
- Gunn, Donald.*—Nests, eggs, and skins, from Selkirk settlement.
- Hale, Dr.*—Skins of mammals from Essex county, N. Y.
- Halifax, Boys of National School.*—Marine shells from Halifax.
- Hanks, Capt. Julian.*—Fishes and shells from Socorro Island.
- Hardisty, W. L.*, through *R. Kennicott*.—Fossil bones, skins of birds, and plants from the upper waters of the Yukon.
- Hardisty, Mrs. W. L.*, through *R. Kennicott*.—Mammals and eggs from Great Slave Lake.
- Harrington, Capt.*—Star-fishes from Mt. Desert.
- Haszliński, Prof. F.*—Dried plants from Eperies, Hungary.
- Hayes, Dr. S.*—Alligator's eggs, insects in alcohol, from Aspinwall, and shells from Navy Bay.
- Haymond, Dr. R.*—Nests and eggs from Brookville, Indiana.
- Henry, W. A.*—Fishes in Alcohol, from Labrador.
- Hepburn, Jas.*—Eggs from San Francisco.
- Hiawasse College.*—Hymenoptera, from Tennessee.
- Hildreth.*—See *Lt. Mullan*.
- Hillier, S. L.*—Indian pipe, Fort Carver, Minnesota.
- Hinman, W. M.*—Skin of *Vespertilio pruinus*, Platte river.
- Hitz, John.*—Series of minerals from United States and Switzerland.
- Holder, Dr. J. B.*—Birds and alcoholic specimens from Tortugas, and eggs of terns and pelicans from Florida.
- Holman, Dr.*—Skin of sea eel, from coast of Lower California.
- Hopkins, A.*—Eggs from Massachusetts.
- Hoy, Dr. P. R.*—Nests, eggs, and birds, from Wisconsin.
- Hubbard, Samuel.*—Japanese seeds and tea; silver ore from Washoe mine.
- Hulsner, Gustav.*—Insects from vicinity of New York.
- Irwin, Dr., U. S. A.*—Minerals, skins, reptiles, and fishes in alcohol, from New Mexico; skins of birds, including male and female Mexican wild turkey, with nests and eggs of birds.
- Janney, N.*—*Neotoma floridana*, and skin of Connecticut warbler, Loudoun county, Virginia.
- Jewett, Col. E.*—Jaws of killer whale, off coast of Payta, and fossils from Mt. Lebanon and near Beyrout.
- Jones, Dr. W. L.*—Alcoholic specimens of fishes, reptiles, shells, &c., Georgia.
- Jung, C. F.*—Neuroptera, diptera, &c., from vicinity of New York.
- Kellogg, Hon. Mr.*—Polished gypsum, from Michigan.
- Kellogg, F.*—Nests, eggs, birds, and insects from Wheelock, Texas.
- Kennicott, R.*—Bird skins and alcoholic specimens, Fort William, Lake Superior; skins of birds, mammals, shells, insects, fish, &c., from Fort Simpson, H. B. T.
- Kennerly*—See *Campbell*.
- Kurtz, Capt. J. D.*—Shells of United States coast.
- Kirby, Rev. Mr.*, through *R. Kennicott*.—Eggs and birds from Lake Winnepeg.



- Keyser, Charles.*—Can of alcoholic specimens from Egmont Key, Florida.
- Kite, Wm.*—Larva, and perfect insect of *Clytus* from Pennsylvania.
- Kriehoff, C.*—Eggs from near Quebec.
- Krider, J.*—Forty specimens *Arvicola*, Philadelphia, and *Bassaris* from Mexico.
- Laszlo, C.*—Alcoholic specimens from Mexico.
- Latimer, Dr. J. T.*—Cast of arca, Virginia.
- Lander, Col. F. W.*—Reptiles and mammals, collected by J. S. Snyder, (including *Lagomys princeps*.)
- Lapham, Dr. J. A.*—Land shells from Wisconsin.
- Laver, F.*—Borings of an artesian well at Reading, Vermont.
- Lazar, Count Coloman.*—Fossil land shells from Laswaro, and recent land shells from Transylvania.
- Le Conte, Dr. J. L.*—Mammals, reptiles, and astaci, types of Major Le Conte's species.
- Lewis, James.*—Shells from Mohawk, New York.
- Libhart, Messrs. A. C. & S. S. H.*—Nests and eggs from Marietta, Pa.
- Lincoln, Charles D.*—Birds' eggs from Massachusetts.
- Lindholm, Capt.*—Shells from Magdalena bay.
- Lindheimer, F.*—Salamanders from Texas.
- Lockhart, Jas.*—Skin of Rocky Mountain goat, robe of musk-ox, and fossils from Mackenzie's river district.
- London Zoölogical Society.*—Egg of summer duck from garden of the Zoölogical Society.
- McCarthy, C. S.*—See *J. H. Clark*.
- Macomb, Capt. J. M.*—Collections of geology and natural history, from New Mexico, chiefly collected by Dr. J. S. Newberry.
- Mactavish, George F.*—Skins of weasels and birds from Hudson's bay.
- Mactavish, Wm.*—Ptarmigans, small mammals, fishes, &c., from Fort Churchill, H. B. T.
- McAllister, W.*—Skin of evening grosbeak, from Racine.
- McCown, Capt. J. P., U. S. A.*—Skins of birds, &c., from Fort Randall.
- McCurdy, L. R. S.*—*Pentremites florealis*, &c., from Indiana.
- McDonald, M.*—Fossils from Lexington, Va.
- McFarlane, R., per B. R. Ross.*—Skin of barren ground bear, Esquimaux dress, and other articles from Lower Mackenzie's river.
- McKenzie, Alexander, per B. R. Ross.*—Mammals and birds from Fort Liard.
- McKenzie, J.*—Skins of birds, and eggs from James' bay.
- McLean, W. M.*—Two hawk's eggs from Virginia.
- Mallet, Prof. J. W.*—Shells from near Mobile.
- Mallory, Hon. Robert.*—Tooth of fossil horse, Big Bone Lick, Ky.
- Marsh, Geo. P.*—Native sulphur from Sicily.
- Marston, Rev. S. W.*—Insects and eggs of birds from Iowa.
- Mastin, Geo. W.*—Eggs, shells, and alcoholic specimens, from St. George Island.
- Michell, Rev. F. A.*—Bear skull and fossil invertebrates, from Phantom Hill, Iowa.
- Morgan, Mr.*—Eggs from Fairmount, Va.

- Mullan, Lieut.*—Fish, birds, eggs, and nests, and alcoholic specimens, from Rocky Mountains, collected by J. Pearsall.
- Mullan, Lieut.*—Zoölogical, mineralogical, and botanical collections from Rocky Mountains, between Coeur d'Alene and Fort Benton, made by Mr. Hildreth.
- Murray, W.*—Cones, leaves, and wood of coniferae, from California.
- Navarro, Don Ramon*, per *J. Xantus*.—Living jays and *Bassaris* from Cape St. Lucas.
- Newberry, Dr. J. S.*—See *Macomb*.
- Newberry, Dr. J. S.*—Shells from various localities.
- Newton, Alfred.*—Skins of lemming and hare, collected on voyage of ship *Enterprise*, Arctic America.
- Mason, W. A.*—Fluviatile shells from western New York.
- Ojeda, Don Marcellino*, per *J. Xantus*.—Dried plants from Cape St. Lucas.
- Osio, Don Juan*, through *J. Xantus*.—Shells from Cape St. Lucas.
- Osio, Donna Beatrice*, through *J. Xantus*.—Coleoptera from Cape St. Lucas.
- Packard, A. S.*—Nests and eggs from New Brunswick.
- Page, Capt. T. J., U. S. N.*—Zoölogical, botanical, and geological collections from La Plata expedition.
- Paine, C. S.*—Eggs and birds from Vermont.
- Parker, S. M.*—Insects, &c., from Massachusetts.
- Patent Office.*—Ancient Roman sarcophagus, brought from Beyrout by Com. J. D. Elliott; marble slab from the plains of Marathon, brought by Com. Elliott; also, two picture frames made of hickory and live oak, a part of the latter from the old frigate *Constitution*. (These frames inclose accounts of the two preceding articles.)
- Peale, T. R.*—Plaster mold for making casts of a stone tablet from the ruins of Palenque, in Central America.
- Pearsall, J.*—See *Lieut. Mullan*.
- Pedrin, Don Antonio*, through *J. Xantus*.—Insects and birds from Cape St. Lucas.
- Peña, Don J. R.*—Seventy species eggs of birds from Chili, South America.
- Peters, Dr. Thos. M.*—Skin of blackbird.
- Philadelphia Academy Natural Sciences.*—Duplicates of Mexican reptiles from Xalapa; skeletons and skulls of mammals in exchange.
- Pickering, Capt., U. S. N.*—Diptera from Cape Florida; shells and other marine animals from Key West.
- Poey, Prof. F.*—Fishes and birds from Cuba.
- Poole, H.*—Specimens of nitro-boro-calcite, *Productus lyelli*, fossil plants, shells, &c., from Windsor, N. S.
- Pope, Capt. J., U. S. A.*—Alcoholic specimens from New Mexico.
- Porter, Com., U. S. N.*—Fishes from west coast of Central America.
- Potts, John.*—Reptiles and birds from Chihuahua.
- Pourtales, L. F.*—Fishes and crustaceans from Florida.
- Purchased.*—Cast of gorilla skull, Gaboon.
- Rankin, James.*—Shells from Long Island.
- Ravenel, Dr.*—Fungi of South Carolina, (Fasciculus V.)

- Raynolds, Capt. W. F., U. S. A.*—Specimens of natural history from upper Missouri, collected by Dr. Hayden; and of zoölogy, by G. H. Trook, Jas. Stevenson, and Wm. Vincent.
- Reed, Peter.*—Lower jaw of *Ursus americanus*, from a peat bog in Washington county, New York; *Larus arcticus*, from Washington county, New York.
- Reed, Wm. M.*—Skins and eggs of birds from Racine, Wisconsin.
- Reid, J.*—Skins of birds, eggs, mammals, &c., Great Slave Lake.
- Remond, Mr.*—Fossils from Cache le Poudre.
- Richards, Frank.*—Eggs of *Pyrranga aestiva*, Fairfax county, Va.
- Roberts, J. H.*—Shells, &c., from Illinois.
- Ross, B. R.*—Very complete collections of animals, plants, eggs, &c., from the Mackenzie River District.
- Rousseau, W. A.*—Birds nests from Troy, New York.
- Rowell, Rev. Jos.*—Shells from California.
- Riise, A. H.*—*Conurus xantholaemus*, from St. Thomas; and ophiurans, reptiles, &c., from West Indies.
- St. Charles College, La.*—Coleopterous insects, birds, and reptiles, from Louisiana.
- Samuels, E.*—Microscopic slides.
- Sartorius, Dr. C.*—Crustaceans, insects, and vertebrates, from near Vera Cruz.
- Salvin, O.*—One hundred and thirty species Guatemala birds.
- Schafhirt, F.*—Skeleton of *Cistudo carolinensis*, from the District of Columbia.
- Schneider, L.*—Skins of birds.
- Schoonover, Major.*—Robe of grizzly bear skin from Yellow Stone river.
- Schott, A.*—Shells from Humboldt Bay, New Granada.
- Schultz, Wm.*—Living alligator, from Georgia.
- Sclater, P. L.*—Skins of birds from Mexico and Jamaica.
- Sherman, Capt.*—Shells from Magdalena Bay.
- Shumard, Dr. B. F.*—Insects from Texas.
- Simonds, E.*—Skins of mammals, birds, skeletons, &c., from Essex county, New York.
- Simpson, Capt. J. H.*—Minerals and rocks from Utah, collected by H. Engelmann.
- Hilton, J. Avery.*—Reptiles, fishes, shells, and two living Sirens, from Georgia.
- Sack, Dr. J. H.*—Eggs of grebe and tern, from Minnesota.
- Stagle, Mr.*—Eggs and tertiary fossils from Virginia.
- Smith, Dr. J. Bryant.*—Birds, reptiles, insects, crustaceans, and seeds, from Jamaica.
- Somers, Dr., through Dr. Bohrer.*—Quartz crystal from Virginia, inclosing a drop of water.
- Snyder, J. S.*—See *Lander*.
- Stagg, T. J.*—Seventeen-year locust, from Pennsylvania.
- Stair, D. F.*—Old cup, coin, and beetle, from Hanover, Pennsylvania.
- Stanley, J. S. A.*—Fossils from Los Angeles, California.
- Stearne, Mrs. J. S.*—Portion of Stump of a tree which stood in front of Washington's marquee, at Valley Forge, Pa., in the winter of 1777-78.

- Sternbergh, S.*—Alcoholic specimens from Panama.
- Stewart, George.*—Skins of reptiles, nests, eggs, insects, &c., from Alabama.
- Stimpson, Wm.*—Alcoholic specimens and shrew, from the coast of Maine.
- Stone, Capt. C. P.*—Shells from Gulf of California, collected in part by F. Fitch, Esq.
- Swan, Jas. S.*—Shells, sponges, and other specimens of natural history, from Ne-ah Bay, W. T.
- Swanston, Thos.,* per *R. Kennicott.*—Skins of *Arvicola*, birds, &c., from Great Slave Lake.
- Suckley, Dr. George.*—Birds, eggs, mammals, and alcoholic specimens, from Fort Kearny and Fort Laramie.
- Taylor, N.,* per *B. R. Ross.*—Skin of young musk ox, from Fort Norman.
- Tolman, J. W.*—Eggs from Winnebago, Illinois.
- Totten, Gen. Jos. G., U. S. A.*—Minerals from California.
- Tracy, Henry.*—Eggs, skin of night-heron, and fish, from coast of Maine.
- Travers, Capt. D. B.*—Duck eggs with black shells, from Virginia.
- Turner, Mr.*—Skins of squirrels from Hanno Bay.
- Uhler, P. R.*—Neuroptera for Dr. Hegan.
- Unknown.*—Shells from Monroe county, Mo.
- Unknown.*—Living green snake, *Letophis aestivus*.
- Unknown.*—Humming birds' nests.
- Unknown.*—Living Carolina rail.
- Vanskiver, Jas.*—Remora from Blackstone Island, Potomac river.
- Veatch, Dr. J. A.*—Shells from California.
- Venable, T. P.*—Bones of the head of a *Delphinus*, from the Pacific.
- Villaescusa, Donna Francisca,* per *J. Xantus.*—Large shells from Cape St. Lucas.
- Villasana, Donna Jesus,* per *J. Xantus.*—Shells from Cape St. Lucas.
- Vogel, C.*—Box of coleoptera, from Rhineland, Mo.
- Wallace, J. W.*—Serpents and dried *Amphiuma*, from Louisiana.
- Walsh, D. B.*—Diptera, hymenoptera, and neuroptera, from Illinois.
- War Department.*—Mass of native copper, from Ontonagon, Michigan.
- Warren, Geo. B.*—Eggs from New York.
- Welch, Geo. W.*—Mounted skunk, red-necked grebe, nests, and eggs, from Massachusetts.
- West, Silas.*—Orthopterous insects from Maine.
- Wharton, Jos.*—Specimens of zinc and spelter.
- White, Lieut. J. W.*—Marine invertebrates, radiata, &c., from Puget Sound.
- Wilcox, H. B.*—Nests, eggs, shells, and alcoholic specimens from Michigan.
- Willis, J. R.*—Skins of birds, eggs, shells, &c., from Halifax.
- Williamstown College Lyceum.*—Nests and eggs from Labrador and Greenland.
- Windle, J. E.*—Eggs of cooper's hawk and skin of snow bird.
- Winston, W. G.*—Lepidoptera and skins and eggs of birds from Halifax.

- Winslow, R. K.—Skin of duck and eggs of birds from Ohio.
- Wood, Wm. S.—Nests and eggs of *Geothlypis macgillivrayi* from Pike's Peak.
- Wood, John C.—Dead alligator from Georgia.
- Wood, Dr. Wm.—Skin of *Accipiter fuscus*, shrew, and nests and eggs, from E. Windsor Hill, Conn.
- Worthen, Prof. A. H.—Types of fossils from Illinois.
- Woodbury, U. S. A., Capt. D. P.—Birds from Tortugas.
- Wright, J. J.—Portion of an Indian ax from Williamstown, N. C.
- Wyman, Prof. J.—*Rana sinuata* from Adirondac Mountains; casts of head of Flat-Head Indian, and skull of Gorilla.
- Wright, C.—See Bradford.
- Xantus, J.—Very large collections of animals, eggs, plants, &c., of Cape St. Lucas.

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#### LIST OF SMITHSONIAN PUBLICATIONS DURING 1860.

Astronomical Observations in the Arctic Seas. By Elisha Kent Kane, M. D., U. S. N. Made during the second Grinnell Expedition in search of Sir John Franklin, in 1853, 1854, and 1855, at Van Rensselaer Harbor and other points in the vicinity of the northwest coast of Greenland. Reduced and discussed by Charles A. Schott, Assistant United States Coast Survey; quarto, pp. 56, and one plate. (Published May, 1860.)

On Fluctuations of Level in the North American Lakes. By Chas. Whittlesey; quarto, pp. 28, and two plates. (Published July, 1860.)

Meteorological Observations, made at Providence, R. I., extending over a period of twenty-eight years and a half, from December, 1831, to May, 1860. By Alexis Caswell, Professor of Natural Philosophy and Theology in Brown University, Providence, R. I.; quarto, pp. 188. (Published October, 1860.)

Meteorological Observations, made near Washington, Ark., extending over a period of twenty years from 1840 to 1859, inclusive. By Nathan D. Smith, M. D.; quarto, pp. 96. (Published October, 1860.)

Researches upon the Venom of the Rattlesnake, with an investigation of the anatomy and physiology of the organs concerned. By S. Weir Mitchell, M. D., Lecturer on Physiology in the American Medical Association; quarto, pp. 156, and twelve wood cuts. (Published December, 1860.)

The preceding compose vol. XII of Smithsonian Contributions to Knowledge.

Tidal Observations in the Arctic Seas. By Elisha Kent Kane, M. D., U. S. N. Made during the second Grinnell Expedition in search of Sir John Franklin, in 1853, 1854, and 1855, at Van Rensselaer harbor. Reduced and discussed by Charles A. Schott, Assistant United

States Coast Survey; quarto, pp. 90, and four plates. (Published October, 1860.)

Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the Institution for the year 1859. 1 volume, 8vo., pp. 450; fifty-five wood cuts.

Instructions in reference to collecting nests and eggs of North American birds. 8vo., pp. 22; eighteen wood cuts.

Circular in reference to the history of North American grasshoppers. 8vo., pp. 4.

Circular in reference to collecting North American shells. 8vo., pp. 4.

Circular in reference to the degrees of relationship among different nations. 8vo., pp. 34.

Circular to officers of the Hudson's Bay Company. 8vo., pp. 6.

Check Lists of the Shells of North America, prepared for the Smithsonian Institution by Isaac Lea, P. P. Carpenter, W. Stimpson, W. G. Binney, and Temple Prime. 8vo., pp. 44.

List of duplicate shells collected by the United States Exploring Expedition under Capt. C. Wilkes, U. S. N. *Indo-Pacific Fauna*. 8vo., pp. 4.

Catalogue of the described Lepidoptera of North America. Prepared for the Smithsonian Institution by John G. Morris. 8vo., pp. 76.

# LIST OF METEOROLOGICAL STATIONS AND OBSERVERS

FOR THE YEAR 1860.

## BRITISH AMERICA.

Name of observer.	Station.	N. latitude.	W. longitude.	Height.	Instruments.*
		° ' .	° ' .	<i>Feet.</i>	
Acadia College .....	Wolfville, Nova Scotia.....	45 06	64 25	95	A.
Baker, J. C .....	Stanbridge, Canada East, (P. O. Saxe's Mills, Vt.)	45 08	73 00	.....	T.
Connolly, Henry .....	Rigolet, Labrador .....	.....	.....	.....	B. T.
Craigie, Dr. W.....	Hamilton, Canada West.....	43 15	79 57	.....	B. T.
Delaney, Edward M. J.	Colonial Building, St. John's Newfoundland.	47 35	52 40	170	B. T. R.
Gunn, Donald .....	Red River Settlement, Hudson's Bay Territory.	50 06	97 00	853	T. R.
Hall, Dr. Archibald.....	Montreal, Canada East.....	45 30	73 36	57	A.
Hensley, Rev. J. M.....	King's College, Windsor, Nova Scotia.	44 59	64 07	200	A.
Magnetic Observatory...	Toronto, Canada West.....	43 39	79 21	†108	A.
Smallwood, J.....	Moose Factory, Hudson's Bay Territory.	51 15	80 45	.....	B.
Rankin, Colin .....	Michipicoton, Canada West.....	47 50	85 05	.....	T.
Ross, Bernard R.....	Fort Simpson, Hudson's Bay Territory.	61 51	121 25	.....	T.
Royal Engineers.....	Halifax, Nova Scotia.....	44 39	63 37	8	A.
Smallwood, Dr. Charles.	St. Martin, Isle Jesus, Can. E..	45 32	73 36	118	A.

## ALABAMA.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	<i>Feet.</i>	
Alison, H. L., M. D.....	Carlowville...	Dallas.....	32 10	87 15	400	T. R.
Cobbs, Rev. R. A .....	Union Town.	Perry .....	32 30	87 31	.....	N.
Poster, William L.....	Montgomery.	Montgomery.	32 22	86 31	.....	N.
Harding, Col. Horace.....	Boligee .....	Greene .....	32 46	88 10	240	B. T. R.
Huston, Thomas A.....	Orrville .....	Dallas.....	32 25	87 06	200	T. P.
Coleman, John A.....						
Jennings, Dr. S. K.....	Orrville .....	Dallas.....	32 24	87 06	.....	T. P. R.
Smith, Rev. Stephen U....	Livingston ...	Sumter .....	32 30	88 16	180	T. P.
Tutwiler, Henry .....	Havana .....	Greene .....	32 50	87 46	500	T. R.
Waller, Robert B.....	Greensboro'..	Greene .....	32 40	87 34	350	A.

\* A signifies Barometer, Thermometer, Psychrometer, and Rain Gauge.  
 B signifies Barometer.  
 T signifies Thermometer.

P signifies Psychrometer.  
 R signifies Rain Gauge.  
 N signifies No Instrument.  
 † Above Lake Ontario.

## ARKANSAS.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' "	° ' "	Feet.	
Blackwell, W. H.....	Perryville.....	Perry.....	35 05	93 16	.....	N.
Buckner, Rev. H. F.....	Micco.....	Creek Nation.	35 00	97 00	.....	T.
Burris, Robert, M. D.....	Green Grove...	Conway.....	.....	.....	.....	N.
Coulter, B. F.....	Brownsville.....	Prairie.....	34 50	92 00	.....	N.
Featherston, George W...	Waldron.....	Scott.....	34 53	94 00	.....	N.
Female College.....	Arkadelphia...	Clark.....	34 08	93 00	.....	N.
Finley, P. F.....	Spring Hill.....	Hempstead...	33 30	93 40	.....	T.
Reynolds, J.....	Yellville.....	Marion.....	36 30	93 00	1,000	T.
Flippin, W. B.....	Bentonville...	Benton.....	36 23	94 10	1,790	N.
Graham, Paul.....	Mount. Home	Marion.....	36 15	92 30	.....	R.
Howard, J. J.....	Doaksville.....	Choct. Nation.	33 45	95 26	.....	N.
McBeth, Miss Sue.....	Jacksonport...	Jackson.....	35 36	91 16	.....	T.
Martin, G. Alex., M. D...	Spring Hill.....	Hempstead...	33 30	93 40	.....	T.
Reynolds, J.....	Washington...	Hempstead...	33 44	93 41	.....	T. R.
Smith, Dr. N. D.....	Yellville.....	Marion.....	36 30	93 00	1,000	N.
Weast, J. W.....						

## CALIFORNIA.

Ayres, W. O., M. D.....	San Francisco.	San Francisco.	37 48	122 27	130	A.
Boucher, Wesley K.....	Mokelumne Hill.	Calaveras.....	38 18	120 28	1,502	N.
Canfield, Colbert A., M. D.	Monterey.....	Monterey.....	36 36	121 54	40	T. P. R.
Frombes, Prof. Oliver S...	Santa Clara....	Santa Clara....	37 18	122 00	100	A.
Gordon, Robert.....	Auburn.....	Placer.....	38 54	121 12	1,176	T.
Howe, Edwin.....	Martinez.....	Contra Costa..	31 00	122 06	20	N.
Kibbe, T. R., M. D.....	Downieville...	Sierra.....	39 27	.....	2,200	T. R.
Logan, Thos. M., M. D..	Sacramento....	Sacramento....	38 35	121 28	41	A.
Randall, Robert B.....	Del Norte.....	Del Norte.....	41 45	124 11	12	T.
Slaven, James.....	Honcut.....	Yuba.....	39 25	121 30	.....	T. R.
Dunkum, Mrs. E. S.....	Meadow Valley	Plumas.....	40 20	120 15	3,700	B. T. R.
Whitlock, James H.....						

## DISTRICT OF COLUMBIA.

MacKee, Rev. C. B.....	Georgetown...	Washington...	38 54	77 03	.....	T. R.
Smithsonian Institution...	Washington...	Washington...	38 53	77 01	60	A.

## CONNECTICUT.

Harrison, Benjamin F....	Wallingford...	New Haven...	41 27	72 50	133	A.
Hunt, Rev. Daniel.....	Pomfret.....	Windham.....	41 52	72 23	587	A.
Johnston, Prof. John....	Middletown....	Middlesex.....	41 32	72 39	175	A.
Rankin, James.....	Saybrook.....	Middlesex.....	41 18	72 20	10	T. R.
Rockwell, Charlotte.....	Colebrook.....	Litchfield.....	42 00	73 06	.....	T.
Yeomans, William H.....	Columbia.....	Tolland.....	41 40	72 42	.....	T.



DACOTAH.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
Norvell, Freeman .....	Greenwood .....		° ' 42 52	° ' 98 24	Feet. 1,900	T. R.

FLORIDA.

Abert, Thayer.....	Warrington ...	Escambia .....	30 21	87 16	9	A.
Alien, George D.....	Magnetic Ob- servatory, Key West.	Monroe .....	24 33	81 48	6	B. T. P.
Bailey, James B.....	Gainesville.....	Alachua.....	29 35	82 26	184	T. R.
Baldwin, A. S., M. D....	Jacksonville...	Duval .....	30 15	82 00	14	A.
Bean, Dr. James B.....	Micanopy.....	Alachua .....	29 35	82 31	78	A.
Dennis, William C.....	Key West.....	Monroe .....	24 33	81 28	16	B. T. R.
Gibbon, Lardner.....	Tallahassee...	Leon.....	30 29	84 07	.....	T.
Ives, Edward R.....	Lake City.....	Columbia .....	30 12	82 37	174	T. R.
Mauran, P. B., M. D.....	St. Augustine.	St. John's.....	29 48	81 35	8	B. T. R.
Steele, Judge Augustus..	Atsena Otie....	Levy .....	29 08	83 04	17	B. T. R.
Whitner, Benjamin F.....	Tallahassee....	Leon.....	30 24	84 17	70	T.

GEORGIA.

Anderson, James, M. D..	Thomaston....	Upson .....	32 56	84 30	750	A.
Camp, Benjamin F.....	Covington .....	Newton.....	33 40	84 00	763	N.
Doughty, Dr. William H.	Augusta.....	Richmond.....	33 27	81 33	152	A.
Gibson, R. T.....	Savannah .....	Chatham .....	32 02	81 01	18	T. R.
Pendleton, E. M., M. D..	Sparta .....	Hancock .....	33 17	83 09	550	T. R.
Seavey, Charles C.....	Cuthbert .....	Randolph .....	.....	.....	.....	T.
Van Buren, Jarvis.....	Clarksville....	Habersham....	34 35	83 31	1,632	T. P.
Westmoreland, J.G., M.D.	Atlanta.....	Fulton .....	33 45	84 31	1,050	B. T. R.

ILLINOIS.

Aldrich, Verry.....	Tiskilwa .....	Bureau.....	41 15	89 66	550	N.
Allison, Jesse.....	Bloomington..	McLean.....	40 30	89 00	.....	N.
Armstrong, M. C.....	Chicago.....	Cook .....	.....	.....	.....	B. T.
Roe, James H.....						
Babcock, Andrew J,.....	Aurora.....	Kane .....	41 41	88 17	650	T. R.
Babcock, E.....	Riley .....	McHenry .....	42 11	88 20	760	T. R.
Bacon, E. E.....	Willow Creek.	Lee.....	41 45	88 56	1,040	T.
Baker, Nathan T.....	Belleville.....	St. Clair .....	38 29	90 06	600	B. T.
Baldwin, Elmer.....	Farmbridge....	La Salle.....	41 13	88 51	600	T.
Ballou, N. E., M. D.....	Sandwich.....	De Kalb.....	41 31	88 30	575	T. R.
Bassett, George R.....	Woodstock....	McHenry.....	42 18	88 30	.....	T. R.
Boettner, Gustav A.....	Chicago.....	Cook .....	41 54	89 40	.....	B. T.
Bowman, Dr. E. H.....	Edgington .....	Rock Island...	41 25	90 46	686	T. R.
Brendel, E., M. D.....	Robinson's Mills.	Menard .....	40 00	90 00	.....	T. P.
Brendel, Frederick, M.D.	Peoria .....	Peoria .....	40 43	89 30	460	A.

## ILLINOIS—Continued.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
Brickenstein, Rev. H. H.	Olney.....	Richland.....	.....	.....	.....	T. R.
Brookes, Samuel.....	Chicago.....	Cook.....	42 00	87 30	.....	T.
Cobleigh, N. E.....	Lebanon.....	St. Clair.....	38 37	89 56	.....	B. T. R.
Collier, Prof. Geo. H.....	Wheaton.....	Du Page.....	41 49	88 06	682	A.
Ellsworth, Milton S.....	Naperville.....	Du Page.....	41 46	88 11	.....	T.
Grant, John.....	Manchester.....	Scott.....	39 33	90 34	683	A.
Haeuser, Emil.....	Galena.....	Jo Daviess.....	.....	.....	.....	N.
Harris, J. O., M. D.....	Ottawa.....	La Salle.....	41 20	88 47	500	T. R.
Little, J. Thomas.....	Dixon.....	Lee.....	41 45	89 31	.....	N.
Mead, S. B., M. D.....	Augusta.....	Hancock.....	40 10	91 00	*203	T. P. R.
Mead, Dr. Thompson.....	Batavia.....	Kane.....	41 52	88 20	636	A.
Newcomb, John B.....	Elgin.....	Kane.....	42 00	88 15	777	A.
Pashley, J. S., M. D.....	Osceola.....	Stark.....	41 16	90 17	.....	T. R.
Riblet, J. H.....	Pekin.....	Tazewell.....	40 36	89 45	.....	T. R.
Rogers, O. P. and J. S.....	Marengo.....	McHenry.....	42 14	88 38	842	B. T. R.
Sherman, Rev. D. H.....	Channahon.....	Will.....	41 15	88 16	643	B. T.
Shotwell, Samuel L.....	Ottawa.....	La Salle.....	41 21	88 39	.....	T.
Smith, Charles E.....	Evanston.....	Cook.....	42 10	87 30	†18	T.
Smith, George O., M. D.....	Ottawa.....	La Salle.....	40 57	87 55	551	T. R.
Titze, Henry A.....	West Salem.....	Edwards.....	38 30	88 00	.....	T. R.
Tolman, James W.....	Winnebago Depot.	Winnebago.....	42 17	89 12	900	B. T. R.

## INDIANA.

Anderson, H. H.....	Rockville.....	Parke.....	36 00	87 00	1,100	N.
Austin, W. W.....	Richmond.....	Wayne.....	39 47	84 47	800	T.
Bartlett, Isaac.....	Logansport.....	Cass.....	40 45	86 13	600	T. R.
Bullock, J. T.....	Shelbyville.....	Shelby.....	39 00	87 00	.....	N.
Chappellsmith, John.....	New Harmony.....	Posey.....	38 08	87 50	320	A.
Dawson, William.....	Cadiz.....	Henry.....	39 55	85 20	.....	T. R.
Dayton, James H.....	South Bend.....	St. Joseph.....	41 45	86 20	600	N.
Haines, John.....	Richmond.....	Wayne.....	39 52	84 59	.....	B. T.
Larrabee, William H.....	Green Castle.....	Putnam.....	39 30	86 47	800	N.
Smith, Hamilton, jr.....	Cannelton.....	Perry.....	37 57	86 42	450	A.
Webb, Miss G.....	Fort Wayne.....	Allen.....	41 10	85 00	761	N.

## IOWA.

Beal, Dexter.....	Grove Hill.....	Bremer.....	42 45	87 15	.....	T.
Collin, Prof. Alonzo.....	Mount Vernon.....	Linn.....	42 00	91 00	.....	T.
Corse, John M.....	Burlington.....	Des Moines.....	40 53	91 10	‡486	T. R.
Doyle, L. H.....	Waterloo.....	Black Hawk.....	42 30	92 31	.....	N.
Dunwoody, Wm. P. ... }	Davenport.....	Scott.....	41 30	90 38	555	N.
Finley, H. S..... }						
Forey, John C.....	Bellevue.....	Jackson.....	42 15	92 25	.....	T. R.
Foster, Suel.....	Muscatine.....	Muscatine.....	41 26	92 00	.....	N.
Horr, Asa, M. D.....	Dubuque.....	Dubuque.....	42 30	90 52	666	A.
Hudson, A. T., M. D.....	Lyons.....	Clinton.....	41 50	90 10	401	R. T.

\* Above low water mark at Quincy.

† Above Lake Michigan.

‡ Above low water mark in the Mississippi.

IOWA—Continued.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
McConnel, Townsend....	Pleasant Plain.	Jefferson.....	41 07	94 54	950	T. R.
McCoy, Franklin, M. D..	Algona ..	Kossuth.....	43 01	94 04	.....	T.
McCready, Daniel. ....	Fort Madison.	Lee .....	40 37	91 28	.....	T. R.
McKenzie, John M. ....	Fayette .....	Fayette .....	42 51	91 51	1,000	T.
Parvin, Theodore S. ... }	Muscatine.....	Muscatine.....	41 25	92 02	586	A.
Ufford, Rev. John..... }						
Reid, Isaiah .....	Kossuth .....	Des Moines ...	41 00	91 13	.....	N.
Shaffer, J. M., M. D.....	Fairfield .....	Jefferson.....	41 01	91 57	940	A.
Sheldon, Daniel .....	Forestville .....	Delaware .....	42 40	91 50	.....	T.
Williams, H. B. ....	Hesper .....	Winneshek ...	43 30	91 46	720	T.

KANSAS.

Berthoud, E. L.....	Leavenworth..	Leavenworth..	39 19	94 50	809	R.
Blackman, W. J. R.....	Lawrence .....	Douglas.....	39 00	95 12	800	A.
Clarkson, Rev. David....	Fort Riley.....	Riley .....	39 00	96 30	1,300	N.
Drummond, Rev. J. H....	Celestville.....	Lykins.....	38 40	95 16	.....	N.
Ellis, Dr. Wm. T. .... }	Lecompton. ...	Douglas.....	39 03	95 10	760	T.
	Mountain City	Arappahoe....	39 35	105 40	.....	T.
Fish, Lucian .....	Burlingame .....	Shawnee .....	.....	.....	.....	T. R.
Goodnow, Isaac T.....	Manhattan ...	Riley .....	39 13	96 45	1,000	T. R.
Goss, B. F. ....	Neosho Falls..	Woodson .....	38 03	95 31	.....	T. R.
McCormick, Wm. A.....	Lecompton .....	Douglas.....	39 03	95 10	825	T.
Merriam, G. F. ....	Gardner .....	Johnson .....	38 47	95 00	800	T. R.
Millar, John H.....	Wyandot.....	Wyandot.....	39 08	94 31	707	T. R.
Preston, Rev. N. O.....	Manhattan .....	Riley .....	39 13	96 45	.....	N.

KENTUCKY.

Barbage, Joshua C.....	Hardinsburg..	Breckenridge..	37 40	86 15	500	N.
Beatty, O.....	Danville .....	Boyle .....	37 40	84 30	900	B. T. R.
Case, Dr. C. D.....	Beech Fork....	Washington... ..	.....	.....	.....	T. R.
Matson, Andrew .....	Paducah .....	Mt. Cracken... ..	37 00	87 21	.....	N.
Miles, Thomas, H., S. J.	Bardstown .....	Nelson .....	37 52	85 18	.....	A.
Murch, E. M. ....	Russelville .....	Logan .....	.....	.....	.....	N.
Savage, Rev. G. S., M. D.	Millersburg....	Bourbon .....	38 40	84 27	804	B. T. R.
Swain, John, M. D.....	Ballardsville ..	Oldham .....	38 36	85 30	461	A.
Woodruff, E. N.....	Louisville .....	Jefferson.....	38 20	85 38	.....	A.
Young, Mrs. Lawrence...	Louisville .....	Jefferson.....	38 07	85 24	570	A.

LOUISIANA.

Anthozioz, B. F.....	Grand Coteau.	St. Landry .....	.....	.....	.....	T.
Mankard, Mrs. M. J.....	Independence.	Livingston.....	30 30	90 33	50	N.
Merrill, Edward, M. D...	Trinity .....	Concordia.....	31 37	91 47	68	T. R.

## MAINE.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
Adams, John W .....	Portland .....	Cumberland ...	43 39	70 00	180	N.
Bickford, Calvin .....	Warren .....	Lincoln .....	44 00	70 29	.....	N.
Brackett, G. Emerson .....	Belfast .....	Waldo .....	44 23	69 08	.....	T. R.
Dana, W. D. ....	North Perry ...	Washington ...	45 00	67 06	100	A.
Gardiner, R. H. ....	Gardiner .....	Kennebec .....	44 40	69 46	90	A.
Gould, M. ....	N'th Bridgeton ..	Cumberland ..	44 03	70 45	300	B. T. R.
Guptill, G. W. ....	Cornishville ...	York .....	43 40	70 44	800	T. R.
Johnson, Warren .....	Topsham .....	Sagadahoc .....	44 00	70 00	100	B. T.
Lord, W. G. ....	Limington .....	York .....	43 40	70 45	500	N.
Moore, Asa P. ....	Lisbon .....	Androscoggin.	44 00	70 04	130	T. R.
Nichols, Charles L .....	Bangor .....	Penobscot .....	44 48	68 47	.....	T.
Parker, J. D. ....	Steuben .....	Washington ...	44 44	67 50	50	A.
Pratt, J. Frank, M. D. ...	New Sharon ...	Franklin .....	44 37	70 03	.....	N.
Van Blarcom, James .....	Vassalboro' ...	Kennebec .....	44 28	69 47	.....	T.
Verrill, G. W., jr. ....	Norway .....	Oxford .....	44 10	70 35	.....	T.
West, Silas .....	Cornish .....	York .....	43 40	70 44	784	T. R.
Wilbur, Benj. F. ....	Dexter .....	Penobscot .....	44 55	69 32	700	R.
Willis, Henry .....	Portland .....	Cumberland ..	43 39	70 15	87	A.
Wilson, Dr. J. B. ....	Exeter .....	Penobscot .....	44 58	68 59	.....	T. R.
Wyman, A. H. ....	N'th Belgrade.	Kennebec .....	44 30	69 49	.....	N.

## MARYLAND.

Baer, Miss H. M. ....	Sykesville .....	Carroll .....	39 23	76 57	700	T. R.
Bell, Jacob E. ....	Leitersburg ...	Washington ...	39 35	77 30	.....	T. R.
Goodman, Wm. R. ....	Annapolis .....	Anne Arundel.	38 59	76 29	20	A.
Hanshaw, Henry E. ....	Frederick .....	Frederick .....	39 24	77 26	.....	A.
Lowndes, Benj. O. ....	Bladensburg ...	Prince George.	38 57	76 58	70	T. R.
Stephenson, Rev. Jas. ....	St. Inigoes .....	St. Mary's ..	38 10	76 41	45	A.
Sutton, Rev. A. ....	Chestertown ..	Kent .....	39 12	75 59	.....	A.

## MASSACHUSETTS.

Astronomical Observatory	Williamstown	Berkshire .....	42 43	73 13	725	B. T. R.
Bacon, William .....	Richmond .....	Berkshire .....	42 23	73 20	1,190	T. R.
Brown, Nathan W .....	Topsfield .....	Essex .....	.....	.....	.....	T. R.
Davis, Rev. Emerson .....	Westfield .....	Hampden .....	42 06	72 48	180	A.
Fallon, John .....	Lawrence .....	Essex .....	42 42	71 11	133	A.
Harvard Col. Observatory	Cambridge .....	Middlesex .....	42 23	71 08	80	A.
Metcalf, Jno. G., M. D. ....	Mendon .....	Worcester .....	42 06	71 33	.....	T. R.
Mitchell, Hon. Wm. ....	Nantucket .....	Nantucket .....	41 17	70 06	30	A.
Morse, Geo. M., M. D. ....	Clinton .....	Worcester .....	42 25	71 42	.....	T. R.
Normal School .....	Bridgewater ...	Plymouth .....	42 00	71 00	150	A.
Prentiss, Dr. Henry C. ....	Worcester .....	Worcester .....	42 16	71 48	528	A.
Raymond, George .....	Fitchburg .....	Worcester .....	42 35	71 50	484	P. T. R.
Rodman, Samuel .....	New Bedford ..	Bristol .....	41 39	70 56	90	A.
Scandlin, Rev. Wm. G. ...	Grafton .....	Worcester .....	.....	.....	.....	B. T.
Snell, Prof. E. S. ....	Amherst .....	Hampshire .....	42 22	72 34	267	A.
Whitcomb, L. F. ....	Florida .....	Berkshire .....	42 41	73 02	2,000	N.

MICHIGAN.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
Blaker, Dr. G. H., jr.....	Marquette.....	Marquette.....	46 32	87 41	630	A.
Bowlsby, Geo. W.....	Monroe.....	Monroe.....	41 56	83 30	584	B. T. R.
Campbell, Wm. M., M. D.	Battle Creek...	Calhoun.....	42 20	85 10	825	B. T. R.
Coffin, Matthew.....	Otsego.....	Allegan.....	42 28	85 42	662	N.
Crosby, J. B.....	New Buffalo...	Berrien.....	41 45	86 46	661	B. T. R.
Pitcher, Dr. Zena.....	Detroit.....	Wayne.....	42 24	82 58	597	A.
Horton, L. S.....						
Smith, L. M. S.....	Mill Point.....	Ottawa.....	43 06	86 11	.....	T.
Stockwell, George A.....	Port Huron...	St. Clair.....	43 00	83 00	.....	T. R.
Streng, L. H.....	Grand Rapids.	Kent.....	43 00	86 00	680	T. R.
	Holland.....	Ottawa.....	.....	.....	.....	.....
Strong, Edwin A.....	Grand Rapids.	Kent.....	43 00	86 00	752	T. R.
Walker, Mrs. Octavia C.	Cooper.....	Kalamazoo...	42 40	85 30	690	T. R.
Whelpley, Miss H. I.....	Monroe.....	Monroe.....	41 56	83 23	590	T. R.
Woodard, C. S.....	Ypsilanti.....	Washtenaw ...	42 15	83 47	751	A.

MINNESOTA.

Byers, S. M.....	Princeton.....	Benton.....	45 50	93 45	.....	T. R.
Clark, Thomas.....	Beaver Bay...	Lake.....	47 12	91 19	657	A.
Wieland, C.....						
Garrison, O. E.....	Princeton.....	Benton.....	45 50	93 45	.....	T. R.
	St. Cloud.....	Stearnes.....	45 45	94 23	.....	.....
Hibbard, A. A.....	Burlington.....	Lake.....	47 01	92 30	645	T. R.
Kelley, O. H.....	Itasca.....	Anoka.....	45 16	93 32	856	T.
Riggs, Rev. S. R.....	Pajutazee.....	Brown.....	45 00	94 00	.....	T. R.
Smith, A. C.....	Forest City...	Meeker.....	45 45	96 00	.....	T. R.
Thickstun, T. F.....	Chatfield.....	Fillmore.....	.....	.....	*325	T. R.
Wieland, Henry.....	Beaver Bay ...	Lake.....	47 11	91 25	850	T.

MISSISSIPPI.

Cribbs, J. R.....	Monticello....	Lawrence.....	31 34	90 00	600	T.
	Westville.....	Simpson.....	32 00	90 00	.....	T.
Johnson, Wm. M., M. D.	Hernando.....	De Soto.....	34 45	90 15	770	A.
McCary, Robert.....	Natchez.....	Adams.....	31 34	91 25	264	B. T. R.
Moore, Prof. Albert.....	Grenada.....	Yalobusha....	33 45	90 00	.....	N.
Robinson, Rev. E. S.....	Prairie Line...	Jasper.....	32 10	89 20	.....	A.
Swasey, Col. C. B.....	Yazoo City....	Yazoo.....	32 55	90 31	.....	N.

MISSOURI.

Bailey, S. S.....	Dundee.....	Franklin.....	38 30	90 10	536	T. R.
Bowles, S. B., M. D.....	Greenfield....	Dade.....	37 22	93 41	1,800	N.
Christian, John.....	Harrisonville.	Cass.....	.....	.....	.....	N.

\* Above La Crosse.

† Above low water mark at Memphis.

## MISSOURI—Continued.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	<i>Feet.</i>	
Dalton, O. D.....	Greenville.....	Wayne .....				N.
Dodson, Benjamin D.....	Toronto.....	Camden.....	37 54	92 30		N.
Engelmann, George, M.D.....	St. Louis.....	St. Louis.....	38 37	90 15	481	A.
Fendler, Augustus.....	St. Louis.....	St. Louis.....	38 37	90 16	470	B. T. P.
Finley, R. W.....	Richmond.....	Ray .....	39 16	94 30		N.
Heaston, David J.....	Bethany.....	Harrison.....	40 15	94 00		N.
Horner, W. H.....	Hornersville.....	Dunklin.....	36 03	90 00		T.
Kirby, D. J.....	Carrollton.....	Carroll.....	39 30	93 31		T.
Lunemann, John H.....	St. Louis.....	St. Louis.....	38 40	90 15	475	A.
Maxey, W. F.....	Paris.....	Monroe.....	39 30	92 00	700	T. R.
Myers, J. H.....	Kirksville.....	Adair.....	40 38	92 50	1,000	N.
Sutherland, Norris.....	Boonville.....	Cooper.....	38 55	92 30		N.
Tidswell, Mary Alice.....	Warrenton.....	Warren.....	38 37	91 16	625	T.
Vankirk, W. J.....	Bolivar.....	Polk.....	37 29	92 45		N.
Vogel, Chas.....	Rhineland.....	Montgomery.....	38 42	91 41	*300	T. R.
Weber, Philip.....	Hermann.....	Gasconade.....	38 40	91 27	598	N.
Wells, Wm.....	Stockton.....	Cedar.....	39 36	93 48	800	T. R.
Wilson, Geo. W., jr.....	Lexington.....	Lafayette.....	39 15	93 45		N.
Wyrick, M. L.....	Cassville.....	Barry.....	36 41	93 57	3,000	T. R.

## NEBRASKA.

Allan, James P.....	Omaha City.....	Douglas.....	41 15	96 10	1,300	T. R.
Bowen, Miss Anna M. J.....	Elkhorn City.....	Douglas.....	41 22	96 12	1,000	T.
Hamilton, Rev. Wm.....	Bellevue.....	Sarpy.....	41 08	95 50		T. R.
Pardee, H. C.....	Rock Bluffs.....	Cass.....	40 54	95 54	1,100	T.
Rain, John G.....	Omaha.....	Douglas.....	41 20	95 57	1,400	T. R.
Rosseau, M. C.....	Fort Pierre.....		44 00	100 00		N.
Smith, Charles B.....	Brownville.....	Nemaha.....	40 30	96 00		T.
White, Bela.....	Kenosha.....	Cass.....	40 51	95 54	1,050	N.

## NEW HAMPSHIRE.

Bell, Louis.....	Farmington.....	Strafford.....	43 20	71 00	300	B. T. R.
Bell, Samuel N.....	Manchester.....	Hillsborough.....	42 59	71 28	300	B. T. R.
Brown, Branch.....	Stratford.....	Cods.....	44 08	71 34	1,000	T. R.
Chase, Arthur.....	Claremont.....	Sullivan.....	43 22	72 21	539	B. T. R.
Odell, Fletcher.....	Shelburne.....	Cogs.....	44 23	71 06	700	B. T.
Pitman, Chas. H.....	North Barnstead.....	Bellnap.....	43 38	71 27		T.
Smith, Rufus.....	N. Littleton.....	Grafton.....	44 20	72 13		N.
Wiggin, Andrew.....	Stratham.....	Rockingham.....	43 00	73 35	100	N.

\* Above Missouri river.

NEW JERSEY.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
Allen, Edwin .....	New Bruns- wick.	Middlesex.....	40 30	75 31	90	N.
Thompson, Geo. W. .... }						
Harper, Prof. L. ....	Riceville .....	Monmouth ....	40 24	73 59	111	B. T. P.
Parry, William .....	Cinnaminson ..	Burlington ...	40 00	75 01	83	N.
Watson, George .....	Woodstown. .	Salem . ....	39 39	75 20	30	T. R.
Whitehead, W. A. ....	Newark.....	Essex.....	40 45	74 10	35	B. T. R.
Willis, O. R. ....	Freehold .....	Monmouth....	40 15	74 21	.....	T.

NEW MEXICO.

Wagner, Lieut. O. G. Topographical Engi- neers.	Santa Fé.....	Santa Fé.....	35 04	106 02	6,846	A.
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NEW YORK.

Arden, Thomas B. ....	Garrison's.....	Putnam.....	41 23	74 02	180	T. R.
Aubier, John .....	Fordham .....	Westchester...	40 54	73 57	147	A.
Bartlett, E. B. ....	Vermillion .....	Oswego .....	43 26	77 26	327	T.
Beauchamp, W. M. ....	Skaneateles .....	Onondaga .....	.....	.....	.....	B. T.
Bowman, John.....	Baldwinsville..	Onondaga .....	43 04	76 41	.....	T.
Brown, Rev. John J. ....	Dansville .....	Livingston ...	42 38	77 44	672	A.
Dill, John B. ....	Auburn .....	Cayuga .....	42 55	74 28	.....	T.
Denning, William H. ....	Fishkill Land- ing.	Dutchess.....	41 33	74 18	42	B. T. R.
Dewey, Prof. Chester. }	Rochester.....	Monroe.....	43 08	77 51	516	B. T. R.
Fenner, F. D. .... }						
Frost, Col. E. C. ....	Havana.....	Schuyler .....	42 30	76 31	1,041	T.
Graham, Joseph.....	Utica .....	Oneida .....	43 07	75 13	.....	A.
Grush, James W. .... }	Spencertown..	Columbia .....	42 18	73 32	700	A.
Packard, Levi S. .... }						
Guest, W. E. ....	Ogdensburg....	St. Lawrence.	44 43	75 37	232	R.
Haskin, Wm. L. ....	Troy .....	Rensselaer....	42 44	73 37	58	A.
Heimstreet, John W. ....	Troy .....	Rensselaer....	42 44	73 37	58	A.
Hibbard, A. A. ....	Hermitage .....	Wyoming.....	42 09	78 14	.....	T. R.
Holmes, Dr. E. S. ....	Wilson .....	Niagara.....	43 20	78 56	250	T.
House, John C. ....	Waterford .....	Saratoga .....	42 47	73 39	70	A.
Howell, R. ....	Nichols .....	Tioga .....	42 00	76 32	.....	T.
Ingersoll, J. D. ....	Ilion .....	Herkimer .....	43 00	79 51	.....	N.
Ives, William .....	Buffalo .....	Erie .....	42 50	78 56	600	A.
Kelsey, Kathalo.....	Great Valley..	Cattaraugus ..	42 12	78 45	.....	N.
Mackie, Matthew .....	Clyde .....	Wayne .....	43 10	77 10	400	B. T.
Malcom, Wm. S. ....	Oswego .....	Oswego .....	43 28	76 30	250	B. T. R.
Mathews, M. M., M. D.	Rochester .....	Monroe.....	43 08	77 51	525	A.
Morris, Professor O. W. .	New York .....	New York .....	40 43	74 05	25	A.
Potter, C. D., M. D. ....	Adams Centre.	Jefferson.....	43 48	75 52	632	R.
Russell, C. H. ....	Gouverneur....	St. Lawrence..	.....	.....	.....	B. T.
Salisbury, Elias O. ....	Buffalo.....	Erie .....	.....	.....	.....	T.
Shearer, H. M. ....	Wellsville.....	Allegany.....	42 07	78 06	1,480	T. R.
Slade, Fred. J. ....	New York.....	New York.....	40 45	73 59	79	A.
Spooner, Dr. Stillman....	Wampsville...	Madison .....	43 04	75 50	500	T. R.

## NEW YORK—Continued.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' "	° ' "	Feet	
Sylvester, Dr. E. Ware...	Lyons .....	Wayne .....	40 44	72 54	15	B. T.
Titus, Henry Wm.....	Bellport .....	Suffolk .....	40 37	74 01	54	B. T. R.
Van Kleek, Rev. R. D. }	Flatbush.....	Kings .....	43 06	77 51	600	B. T. P.
Howard, Rev. W. W. }	East Henrietta	Monroe .....	40 44	73 59	41	A.
Wadsworth, A. S.....	New York .....	New York .....	42 55	75 46	1,260	A.
Wakely, Charles C.....	Cazenovia.....	Madison .....	43 40	75 32	.....	T. R.
White, Aaron.....	Houseville ...	Lewis .....	42 45	79 06	680	N.
Yale, Walter D.....	Pine Hill.....	Erie .....				
Zimmerman, Godfrey....						

## NORTH CAROLINA.

Adams, Prof. E. W .....	Goldsborough	Wayne .....	35 20	77 51	102	T. R.
Craven, Rev. B .....	Trinity College	Randolph .....	35 45	80 00	400	A.
Hamilton, W. H. ....	Raleigh .....	Wake .....	35 40	78 52	317	N.
McDowell, Rev. A .....	Murfreesboro'	Hertford. ....	36 30	77 01	.....	A.
Moore, Geo. F., M. D....	Green Plains..	Northampton.	36 32	77 45	.....	T. R.
Phillips, Prof. James, D.D	Chapel Hill....	Orange .....	35 54	79 17	.....	B. T. R.

## OHIO.

Abell, B. F .....	Welshfield ...	Geauga .....	41 23	81 12	1,205	T. R.
Adams, D. P .....	Marietta.....	Washington ..	39 25	81 31	630	T. R.
Allen, Frederick D .....	Oberlin .....	Lorain .....	41 20	82 15	800	A.
Ammen, J. ....	Ripley .....	Brown .....	38 37	83 31	.....	B. T. R.
Anthony, Newton.....	Mount Union.	Stark .....	40 54	81 31	.....	T.
Atkins, Rev. L. S.....	Madison .....	Lake .....	41 49	80 10	.....	T.
Benner, J. F.....	New Lisbon...	Columbiana ...	40 45	80 45	961	B. T. R.
Bowen, Wm. F.....	Sharonville ...	Hamilton.....	39 19	84 30	800	N.
Chapman, N. A.....	Twinsburg....	Summit .....	49 29	81 28	1,050	T.
Clark, Wm. P.....	Medina .....	Medina .....	41 07	81 47	1,255	A.
Colbrunn, Edward .....	Cleveland .....	Cuyahoga.....	41 30	81 40	665	T.
Cotton, D. B., M. D.....	Portsmouth...	Scioto .....	38 45	82 50	529	B. T. R.
Crane, George W.....	Bethel .....	Clermont.....	39 00	84 00	555	T. R.
Davidson, H. M.....	Freedom.....	Portage .....	41 13	81 08	1,100	B. T. R.
Dille, Israel.....	Newark.....	Licking .....	40 07	82 21	825	T.
Fuller, W. G.....	Harmar .....	Washington...	39 24	81 28	631	T.
Gamble, J. W.....	Russell's Sta'n	Highland .....	39 13	83 36	1,000	N.
Hammitt, John W .....	College Hill ..	Hamilton.....	39 19	84 26	800	N.
Hampton, W. C.....	Mt. Victory ...	Hardin.....	40 35	83 36	1,050	N.
Harper, George W.....	Cincinnati.....	Hamilton.....	39 06	84 27	500	A.
Haywood, Prof. John....	Westerville ...	Franklin.....	40 04	83 00	.....	A.
Hill, F. G.....	Dallasburg ...	Warren .....	39 30	84 31	800	N.
Hillier, Rev. Spencer L..	Breckville ...	Cuyahoga.....	41 15	81 30	800	A.
Huntington, George C...	Kelley's Island	Erie .....	41 36	82 42	587	B. T. R.
Hyde, Gustavus A.....	Cleveland .....	Cuyahoga .....	41 30	81 40	643	B. T. R.
Ingram, John, M. D.....	Savannah.....	Ashland.....	41 12	82 31	1,098	A.
King, Mrs. Ardelia C. A.	Madison .....	Lake .....	41 50	81 00	620	T. R.
Lumsden, Rev. Wm.....	West Union ...	Adams .....	.....	.....	.....	T. R.
Luther, S. M.....	Hiram.....	Portage .....	41 20	81 08	1,290	T. R.
Mathews, J. McD., D.D.	Hillsborough..	Highland.....	39 13	83 30	1,134	A.
McClung, Charles L.....	Troy.....	Miami.....	40 03	84 06	1,103	B. T. R.



OHIO—Continued.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' "	° ' "	<i>Feet.</i>	
McMillan, S. B.....	East Fairfield.	Columbiana ..	40 47	80 44	1,152	A.
Peck, Wm. R., M. D.....	Bowling Green	Wood .....	41 15	83 40	700	B. T.
Phillips, R. C. and J. H.	Cincinnati.....	Hamilton.....	39 06	84 27	540	B. T.
Rhoades, Dr. John.....	Hocking Port.	Athens .....	39 00	81 30	.....	N.
Shaw, Joseph.....	Bellefontaine..	Logan .....	40 21	83 20	1,040	T. R.
Shields, Rev. Robert.....	Bellecentre.....	Logan .....	40 30	83 45	1,170	B. T. R.
Spratt, Dr. Wm. W.....	Andrews.....	Morrow.....	40 45	80 45	1,500	T.
Sperry, Mark.....	Croton.....	Licking .....	40 13	82 38	.....	T. R.
Tappan, Eli T.....	Cincinnati.....	Hamilton.....	39 07	84 27	*470	A.
Trombley, J. B., M. D....	Toledo.....	Lucas.....	41 39	82 32	604	B. T.
Tweedy, David H.....	Mt. Pleasant ..	Jefferson .....	40 20	83 34	.....	N.
Ward, Rev. L. F.....	Avon.....	Lorain.....	41 27	82 04	800	A.
Warder, A. A.....	Cincinnati.....	Hamilton.....	39 08	84 35	800	T. R.
Williams, Prof. M. G.....	Urbana.....	Champaign .....	40 06	83 43	1,015	B. T. R.
Wilson, Prof. J. H.....	College Hill...	Hamilton.....	39 19	84 26	800	B. T. R.
Young, Prof. Chas. A., } Barrows, A. C..... }	Hudson.....	Summit.....	41 15	81 24	1,137	B. T. R.

PENNSYLVANIA.

Baird, John H.....	Tarentum.....	Alleghany.....	40 38	79 46	950	T.
Boyers, W. R.....	Freeport.....	Armstrong .....	40 44	79 42	.....	T.
Brewster, Wm., M. D....	Altoona.....	Blair.....	40 30	78 31	1,168	B. T. R.
Brugger, Samuel.....	Huntingdon ..	Huntingdon .....	40 35	78 03	734	B. T. R.
Coffin, Selden J.....	Fleming.....	Centre .....	40 55	77 53	780	T. R.
Houghton, George S.....	Easton.....	Northampton.	40 43	75 16	320	A.
Hook, Thos. E., & Sons }	Bendersville..	Adams .....	.....	.....	.....	N.
Parlington, Fenelon.....	Parkersville ..	Chester .....	39 54	75 37	218	T. R.
Davis, Charles.....	Cannonsburg ..	Washington...	40 17	80 18	936	A.
Eggert, John.....	Berwick.....	Columbia .....	41 05	76 15	583	A.
Friel, P.....	Shamokin.....	Northumber'd	40 15	76 30	700	T. R.
Hance, Ebenezer.....	Norrisville ..	Bucks .....	40 12	74 48	30	B. T. R.
Harvey, J. C.....	Nazareth.....	Northampton.	40 43	75 21	530	B. T. R.
Heckerman, Rev. Henry.	Bedford.....	Bedford .....	40 01	78 30	.....	T. R.
Heisley, Dr. John.....	Harrisburg ..	Dauphin .....	40 16	76 15	.....	B. T. R.
Heyser, William, jr .....	Chambersburg	Franklin .....	39 58	77 45	618	A.
Hickok, W. O.....	Harrisburg ..	Dauphin .....	40 20	76 50	320	A.
Hofer, Dr. Jacob R.....	Mount Joy.....	Lancaster .....	40 08	76 30	.....	A.
Jacobs, Rev. M.....	Gettysburg ..	Adams.....	39 49	77 15	624	B. T. R.
James, Prof. Charles S.	Lewisburg .....	Union .....	40 58	76 58	.....	A.
Kerlin, Isaac N., M. D...	Media.....	Delaware .....	.....	.....	.....	A.
Kirkpatrick, Prof. J. A...	Philadelphia..	Philadelphia..	39 57	75 10	50	A.
Kohler, Edward.....	Whitehall St'n	Lehigh.....	40 40	75 26	250	T.
Martin, K. A.....	Harrisburg ..	Dauphin .....	40 16	76 55	.....	B. T. R.
Martindale, Jos. C., M. D.	Philadelphia..	Philadelphia..	40 05	75 09	.....	N.
Meehan, Thomas.....	Germentown..	Philadelphia..	.....	.....	.....	N.
Mewry, George.....	Somerset.....	Somerset.....	40 00	79 03	2,195	A.
Muller, Prof. Rudolph..	Latrobe.....	Westmoreland	40 27	79 32	985	B. T. R.
Ralston, Rev. J. Grier ...	Norristown....	Montgomery ..	40 08	75 19	153	A.
Saurman, John W.....	Byberry.....	Philadelphia..	40 00	74 49	.....	T. R.
Scott, Samuel.....	Worthington..	Armstrong .....	41 50	79 31	1,050	T. R.
Smith, Wm., D. D.....	Cannonsburg ..	Washington...	40 17	80 10	936	B. T. R.
Speer, Alex. M., M. D....	Pittsburg.....	Alleghany .....	40 32	80 02	850	B. T. R.
Swift, Dr. Paul.....	W. Haverford	Delaware .....	40 00	75 21	400	T. R.
Travelli, John I.....	Sewickleyville	Alleghany .....	40 38	80 14	.....	B. T. R.

\* Above low water in the Ohio river at Cincinnati.

## RHODE ISLAND.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments,
			° ' .	° ' .	Feet.	
Caswell, Prof. A.....	Providence.....	Providence ....	41 49	71 25	120	A.
Sheldon, H. C.....	Providence.....	Providence ....				B. T. R.

## SOUTH CAROLINA.

Cornish, Rev. John H....	Aiken .....	Barnwell .....	33 32	81 34	565	T. R.
Glennie, Rev. Alexander.	Georgetown ...	All Saints .....	33 29	79 17	20	A.
Johnson, Joseph, M. D }	Charleston ...	Charleston ...	32 46	80 00	20	B. T. R.
Dawson, J. L., M. D... }	Black Oak.....	Charleston ...	33 00	80 00	50	A.
Ravenel, Thomas P.....						

## TENNESSEE.

Barney, Chas. R.....	University Pl.	Franklin.....	35 12	86 00	2,000	T. R.
Blake, J. R. ....	La Grange .....	Fayette .....				B. T. R.
Dodge, J. W., & Son.....	Pomona.....	Cumberland ..	36 00	85 00	2,200	T.
Dodge, Stephen C.....	Knoxville .....	Knox.....	35 56		1,000	T.
Houghton, S. W.....	Winchester ...	Franklin.....	35 10	86 11		T. R.
Jennings, S. K., M. D ..	Austin .....	Wilson.....	36 20	86 20	2,000	T. P. R.
Stewart, Prof. Wm. M. ...	Clarkesville ..	Montgomery..	36 28	87 13	481	A.
Mitchell, R. W., M. D...	Memphis .....	Shelby.....	35 08	90 00	262	A.

## TEXAS.

Allis, Melvin H.....	Gonzales .....	Gonzales.....	29 35	97 30		N.
De Jernett, R., M. D.....	Greenville.....	Hunt .....	33 10	97 23		N.
D'Spain, Dr. B. L. .... }	Tarrant.....	Hopkins.....	33 30	96 41		N.
Ewing, J. M.....						
Freese, G.....	Boston.....	Bowie.....	33 25	94 40	600	N.
Friedrich, Otto.....	New Braunfels.	Comal.....	29 41	98 15		B. T. R.
Gaffney, James O.....	San Patricio...	San Patricio...	27 45	98 31		T. R.
Gantt, Dr. Wm. H.....	Union.....	Washington ..	30 11	96 31	540	T. R.
Gibbs, T.....	Huntsville.....	Walker.....				R.
Glasco, J. M.....	Gilmer.....	Upshur.....	32 46	94 51	1,017	T. R.
Kaler, Frederick.....	Aransas .....	Refugio .....	27 47	97 08	15	T. R.
Kapp, Ernst.....	Sisterdale .....	Blanco .....	29 54	98 35	1,000	A.
Kellog, F.....	Wheelock.....	Robertson.....	30 50	96 30	450	T. R.
Moke, Dr. James E.....	Woodboro'....	Grayson .....	33 47	96 36		N.
Palm, Swante.....	Austin.....	Travis.....	30 15	97 47		A.
Rucker, B. H.....	Washington...	Washington...	30 26	96 15		B. T. R.
Schumann, Bruno .....	Round Top....	Fayette .....	30 06	96 37		T. R.
Sias, Prof. Solomon .....	Bonham .....	Fannin .....	33 40	96 13	435	A.
Van Nostrand, J.....	Austin.....	Travis.....	30 20	97 46	650	T. P. R.
Wade, F. S.....	Cross Roads..	Williamson...	30 29	97 26	672	T. R.
West, Dr. N. P.....	Burkeville....	Newton .....	31 00	93 31		T.
Yellowby, Prof. C. W....	Webberville ..	Travis .....	30 10	97 31		B. R.
Yoakum, F. L.....	Larissa.....	Cherokee.....	31 45	95 20		T. P. R.

UTAH.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
Pearce, Harrison.....	Washington...	Washington...	37 00	114 00	.....	T. R.
	Heberville.....	Washington...	.....	.....	.....	T. R.
Phelps, W. W.....	Great Salt Lake City.	Salt Lake .....	40 45	111 26	4,260	A.

VERMONT.

Buckland, David.....	Brandon .....	Rutland .....	45 43	73 00	.....	T. R.
Chickering, Rev. J. W ...	Springfield .....	Windsor .....	43 18	72 33	300	T. R.
Cutting, Hiram A. ....	Lunenburg.....	Essex .....	44 28	71 41	1,124	A.
Fairbanks, Franklin.....	St. Johnsbury .....	Caledonia .....	44 25	72 00	540	B. T. R.
Paddock, James A.....	Craftsbury ...	Orleans .....	44 40	72 29	1,100	T. R.
Parker, Joseph .....	West Rupert..	Bennington... ..	43 15	73 11	750	T.
Petty, McK.....	Burlington .....	Chittenden .....	44 27	73 10	367	A.

VIRGINIA.

Abell, J. Ralls.....	Charlottesville	Albemarle.....	38 00	78 31	521	T. R.
Appleyard, John.....	Richmond.....	Henrico .....	.....	.....	.....	T.
Astrop, Col. R. F. ....	Crichton's Store.	Brunswick .....	36 40	77 46	500	T. R.
Bell, L. J. ....	Harper's Ferry	Jefferson.....	.....	.....	.....	T. R.
Dickinson, George C.....	Cobham Depot	Albemarle.....	38 05	78 21	450	T. R.
Ellis, D. H. ....	Wardensville .	Hardy.....	39 30	78 03	1,720	A.
Fraser, James.....	New England.	Wood .....	39 20	81 00	.....	N.
Jones, Silas B.....	Fork Union...	Fluvanna .....	37 40	78 21	.....	N.
Kendall, James E.....	Kanawha C.H.	Kanawa. ....	38 20	81 30	720	T. R.
Lockwood, George P.....	Wheeling .....	Ohio .....	41 09	80 46	.....	T. R.
Meriwether, Charles I. ...	Richmond.....	Henrico .....	.....	.....	.....	T. R.
Marvin, John W.....	Winchester .....	Frederick.....	39 15	78 10	.....	T. R.
Pickett, John.....	The Plains.....	Fauquier.....	38 50	77 51	.....	T.
Purdie, John R., M. D...	Smithfield.....	Isle of Wight..	37 02	76 37	100	T. R.
Robey, Charles H.....	Fredericksb'g.	Spottsylvania.	38 30	77 30	600	N.
Sanders, B. D.....	Wellsburg .....	Brook .....	.....	.....	.....	T. R.
Stalnaker, J. W., M. D...	Lewisburg .....	Greenbrier ...	37 49	80 28	2,000	T. R.
Van Doren, Abram. ....	Falmouth .....	Stafford .....	38 15	77 34	350	T. R.
Webster, Prof. N. B.....	Portsmouth....	Norfolk .....	36 50	76 19	12	B. T. R.

WISCONSIN.

Armstrong, S.....	Caldwell Prairie.	Racine .....	.....	.....	.....	T.
	Pardeeville.....	Columbia .....	43 44	89 16	.....	T.
Atwood, Isaac .....	Lake Mills .....	Jefferson .....	43 00	89 00	.....	N.
Bell, James H.....	Kilbourn City	Columbia.....	43 30	90 00	945	N.
Clarke, Prof. Ambrose W.	Delafield.....	Waukesha.....	43 20	88 31	900	B. T.
Curtis, W. W.....	Rocky Run.....	Columbia .....	43 26	89 20	.....	T. R.
Doyle, L. H.....	Otsego.....	Columbia .....	43 30	.....	.....	N.

## WISCONSIN—Continued.

Name of observer.	Station.	County.	N. latitude.	W. longitude.	Height.	Instruments.
			° ' .	° ' .	Feet.	
Ellis, Edwin, M. D.....	Whittlesey....	La Pointe.....	46 33	91 00	610	T. R.
Gordon, W. A., M. D....	Wausau.....	Marathon.....	45 00	89 30	.....	T. R.
Gridley, Rev. John.....	Kenosha.....	Kenosha.....	42 35	87 50	600	B. T. R.
Jennings, J.....	Madison.....	Dane.....	43 05	89 25	1,068	T. P.
Johnson, A. K.....	Platteville.....	Grant.....	42 45	90 00	.....	T. R.
Lapham, Increase A.....	Milwaukie....	Milwaukie....	43 03	87 54	593	A.
Larkin, Prof. E. P.....	Milwaukie....	Milwaukie....	43 02	87 55	684	B. T.
Lüps, Jacob.....	Manitowoc....	Manitowoc....	44 07	87 45	658	B. T.
Mann, William.....	Superior.....	Douglas.....	46 46	92 03	680	T. R.
Mason, Prof. R. Z.....	Appleton.....	Outagamie....	44 10	88 35	800	A.
Mathews, D. and G.....	Burlington....	Racine.....	42 39	.....	700	N.
Parker, Melzar.....	Weyauwega....	Waupaca.....	45 15	88 50	850	T.
Pease, Dr. Clark G.....	Janesville....	Rock.....	42 43	89 09	780	T.
Phelps, Hiland W.....	Racine.....	Racine.....	42 45	87 48	660	B. T.
Porter, Prof. William.....	Beloit.....	Rock.....	42 30	89 04	750	B. T. R.
Sterling, Prof. J. W....	Madison.....	Dane.....	43 05	89 25	1,068	A.
Clarke, S. P.....						
Struthers, R. H.....	Rural.....	Waupaca.....	44 20	89 05	.....	T.
Winkler, C., M. D.....	Milwaukie....	Milwaukie....	43 03	87 57	600	B. T. R.

## MEXICO.

Name of observer.	Station.	Latitude.	Longitude.	Height.	Instruments.
		° ' .	° ' .	Feet.	
Hieto, J. A.....	Cordova, Vera Cruz.....	18 54	.....	2,820	B. T. R.
Laszlo, Charles.....	Minititlan, Tehuantepec.....	17 59	94 07	60	A.
Sartorius, Charles.....	Mirador, Vera Cruz.....	19 15	96 25	3,600	A.

## CENTRAL AMERICA.

Canudas, Antonio.....	Guatemala College, Guatemala	14 37	90 30	.....	A.
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## WEST INDIES.

Elliot, Jonathan.....	St. Domingo.....	18 28	69 52	70	N.
Crisson, J. C.....	Turk's Island.....	21 30	71 10	15	B. T.
Hamilton, Capt. W.....					
Carothers, A. G.....					

BERMUDA.

Name of observer.	Station.	Latitude.	Longitude.	Height.	Instruments.
Royal Engineers, (in the Royal Gazette.)	Centre Signal Station, St. George's.	..... 0. ' .....	..... 0 ' .....	..... Feet. ....	A.

SOUTH AMERICA.

Hering, C. T.....	Plantation Catharina Sophia, colony of Surinam, Dutch Guiana.	5 48	56 47	.....	A.
Brown, George H.....	Jauja, Peru .....	12 00 S.	75 15	10,500	B. T. P.

*Stations from which telegraphic reports of the weather were received at the Smithsonian Institution in the year 1860.*

Burlington, Vt. New York, N. Y. Philadelphia, Pa. Pittsburg, Pa. Baltimore, Md. Frederick, Md. Hagerstown, Md. Cumberland, Md. Richmond, Va. Petersburg, Va. Norfolk, Va. Staunton, Va. Lynchburg, Va. Grafton, Va. Wheeling, Va.	Parkersburg, Va. Marietta, Ohio. Chillicothe, Ohio. Cincinnati, Ohio. Cleveland, Ohio. Cairo, Ill. Elgin, Ill. Ottawa, Ill. Rock Island, Ill. Cedar Rapids, Iowa. Dubuque, Iowa. St. Louis, Mo. Bristol, Tenn. Knoxville, Tenn. Chattanooga, Tenn.	Raleigh, N. C. Wilmington, N. C. Columbia, S. C. Charleston, S. C. Augusta, Ga. Savannah, Ga. Macon, Ga. Columbus, Ga. Griffin, Ga. Atlanta, Ga. Prairie Bluff, Ala. Montgomery, Ala. Lower Peach Tree, Ala. Mobile, Ala. New Orleans, La.
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LIST OF METEOROLOGICAL MATERIAL CONTRIBUTED IN ADDITION TO THE REGULAR OBSERVATIONS.

- Alcott, William P.*—Observations (thermometer, winds, and clouds,) made on an expedition to Greenland, *via* the Gulf of Newfoundland and Bon Esperance harbor, Labrador, in the schooner Nautilus, Captain Charles E. Rantlett, of Thomaston, Maine, by the Lyceum of Natural History of William's College, Williamstown, Mass., from July 1 to September 20, 1860.
- Ballou, N. E.*—Printed synopsis of observations of temperature, rain, winds, and clouds, for the year 1860, at Sandwich, Illinois.
- Bandelier, A.*—Record of auroras seen at Highland, Illinois, from December, 1859, to November, 1860.

- Blewett, Rev. W.*—Notes and observations for January, February, and March, 1860, at Thomasville, Georgia.
- Bowen, John S.*—Meteorological data from observations made by his daughter near Elkhorn City, Nebraska, from June, 1858, to January, 1861, computed with a view to testing the old German notion that a cold spell always occurs when the moon is in Aries or Taurus.
- Brooke, Lieutenant J. M., U. S. N.*—Barometric and wind observations during a gale at Simoda, August 10, 1859, with graphic representations of this and several other storms.
- Canudas, Antonio.*—Printed summary of meteorological and magnetic observations, for the year 1860, at Guatemala College, Mexico.
- Clarke, Lawrence, Jr.*—Temperature and amount of rain at Fort Rae, Great Slave Lake, Hudson's Bay Territory, from October, 1859, to June, 1860. (Forwarded by Mr. Kennicott.)
- Dawson, William.*—Thermometer observations at Cadiz, Indiana, from September, 1854, to December, 1856.
- Dirmeyer, George William, M. D., Secretary of the Board of Health of New Orleans.*—Report of the Board of Health for 1860, containing full tables of the meteorology of New Orleans for each month, furnished by Dr. S. P. Moore, U. S. A.
- Du Pont, Captain S. F., U. S. N.*—Printed tables of barometer, thermometer, winds, and weather, from May to November, 1859, kept on board a boat, by Mr. J. H. Hendry, chief officer of the Swallow, principally in Chefoo harbor, (lat.  $37^{\circ} 34' N.$ , long.  $121^{\circ} 27' E.$ .) the rendezvous of the French expeditionary forces in the Gulf of Pecheli, a portion of the Chinese coast hitherto little frequented by foreigners.
- Earle, Silas, M. D.*—Register of thermometer kept at Columbia, Tuolumne county, California, 2,200 feet above the level of the sea, from June 16, 1857, to February 19, 1860.
- Fendler, Augustus.*—Half-hourly barometric observations from 9 to 11 a. m., and 3 to 6 p. m., made at Colonia Tovar, Venezuela, from May 17 to December 12, 1857, reduced to  $32^{\circ}$ . (These are the same observations that were published in the report for 1857 without being corrected for temperature.)
- Hourly barometric observations from 5 a. m. to 9 p. m., made at St. Louis, Missouri, from May 29 to June 30, 1860, reduced to  $32^{\circ}$ .
- Frey, Samuel C.*—Newspaper record of barometer and thermometer at Springfield, Ohio, during the years 1859 and 1860, and to March, 1861.
- Humphreys, Captain A. A., U. S. Top. Eng.*—"A lunar tidal wave in Lake Michigan, demonstrated by Brevet Lieutenant Colonel J. D. Graham, Major U. S. Top. Engs.," with diagrams. (Pamphlet.)
- Jewell, Wilson, M. D.*—Report on meteorology and epidemics, read before the College of Physicians of Philadelphia, February 1, 1860. The meteorological observations are from the record of Prof. James A. Kirkpatrick, of the Philadelphia High School. (Pamphlet.)
- Kallussowski, Dr. Henry K.*—Meteorological observations at the Astro-

nomical Observatory, Vilna, Russia, from December 29, 1859, to July 3, 1860. (Manuscript.)

*Kennicott, Robert.*—Observations of rain, clouds, and winds during January and February, 1860, made at Fort Liard, Liard river, Hudson's Bay Territory.

*Kingston, Professor.*—Mean meteorological results at Toronto, Canada East, for the years 1859 and 1860, and comparisons with previous years, by Professor Kingston, M. A., Director of the Provincial Magnetic Observatory at Toronto. (Printed sheets.)

*Kron, F. J.*—Thermometer record kept at Attaway Hill, in Stanley county, N. C., during the years 1836 to 1839 and 1846 to 1860, inclusive.

*Lapham, I. A.*—Copy of manuscript notes of the weather, made by his brother, Darius Lapham, (deceased,) at and near Cincinnati, Ohio, for the years 1832, 1836, 1837.

Table showing the amount of rain and melted snow at Milwaukee, Wisconsin, for each month, season, and year, from 1841 to 1859, inclusive, as measured by Dr. E. S. Marsh, I. A. Lapham, and Dr. Charles Winkler. (Printed in the Bulletin of the Wisconsin Agricultural and Mechanical Association for August, 1860.)

Newspaper scraps relating to the floods, tornadoes, &c., of the western States, in April, May, and June, 1860.

*Light-House Board.*—Registers kept during the year 1860, chiefly without instruments, at one hundred and sixty-six different light stations.

*McKenzie, John.*—Thermometer observations from September 1, 1857, to August 31, 1860, and barometer from September 1, 1858, to August 31, 1860, made at Moose Factory, Hudson's Bay Territory.

*Meade, Capt. George, U. S. Top. Engineers.*—Register of water level and meteorological observations under the direction of Capt. G. Meade, Topographical Engineers, Superintendent Survey of the North and Northwestern Lakes, as follows:

At Sackett's Harbor, N. Y., October, 1859, to December, 1860, by Henry Metcalf.

At Charlotte, N. Y., October, 1859, to December, 1860, by Andrew Mulligan.

At Fort Niagara, N. Y., October, 1859, to December, 1860, by L. Leffman.

At Monroe Piers, Mich., October, 1859, to December, 1860, by John Lane.

At Fort Gratiot, Mich., June, July, and August, 1859, by Lieut. Charles N. Trumbull, Topographical Engineers.

At Thunder Bay, Mich., October, 1859, to November, 1860, by I. I. Malden.

At Ottawa Point, Mich., October, 1859, to December, 1860, by John Oliver.

At Grand Haven, Mich., December, 1859, to December, 1860, by Heber Squier.

At Ontanagon, Mich., October, 1859, to December, 1860, by H. Selby.

- At Michigan City, Ind., October, 1859, to September, 1860, by Wm. Woodbridge, B. D. Angell, and Howard Blake.
- At Superior, Wis., October, 1859, to December, 1860, by George R. Stuntz, assisted by E. H. Bly.
- Morton, Lieutenant J. St. Clair.*—Observations made by the United States Chiriqui Commission at Chiriqui Lagoon, from August 27 to November 14, 1860. Observer, John E. Neill, Third Ass't Eng. U. S. N.
- Navy Department, Bureau of Medicine and Surgery.*—Registers kept at: Philadelphia, 1857, 1858, 1859, and 1860, complete. Pensacola, 1857, 1858, 1859, and 1860, complete, except January to May, 1858. New York, November and December, 1860. Portsmouth, Va., October, November, and December, 1860.
- Pillsbury, M. A.*—Thermometer observations at East Cleveland, Ohio, taken at 7 a. m., and 9 p. m., from 1840 to 1846, inclusive.
- Poole, Henry.*—Meteorological observations at Albion Mines, Pictou, Nova Scotia, latitude  $45^{\circ} 34' 30''$ , longitude  $62^{\circ} 42'$ , from 1843 to 1852, inclusive, viz:
- Mean barometer readings for months and years, corrected for temperature.
  - Extremes of barometer for each month and year.
  - Mean temperature of the months, seasons, and years, with the extremes of heat and cold.
  - Mean and extreme temperature for day and night for each month.
  - Nights of frost, nights below zero, and degrees of frost below zero.
  - Winds and rain, with the number of nights and days on which rain or snow fell.
  - Table of snow storms.
  - Average amount of rain, divided into two seasons, for the information of the working farmer.
- Ravenel, Thomas P.*—Meteorological journal for the years 1859 and 1860, kept in St. John's, Berkely parish, S. C., for the Black Oak Agricultural Society, by T. P. Ravenel, secretary. (Pamphlets.)
- Riter, F. G.*—Observations of thermometer, rain, clouds, and winds, made at Fort Union, Upper Missouri, from August to November, 1857, and January, 1858.
- Ross, Bernard R.*—Meteorological notes at Fort Simpson, Mackenzie's river, Hudson's Bay Territory, from April, 1848, to August, 1859, inclusive; thirty-four sheets; compiled from the post journal, &c., by Bernard R. Ross, chief factor, H. H. B. C. S.
- Shaffer, J. M.*—Summary of observations for each month in the year 1859, made, with a full set of instruments, at Fairfield, Iowa, together with a comparative table of temperature for five years; and also tables of the time of leafing and flowering of plants and the arrival of birds, in 1857, 1858, and 1859. (Printed sheet.)
- Smallwood, Dr. Charles.*—Contributions to meteorology, reduced from observations taken during the year 1859 at St. Martin, Isle Jesus, Canada East, by Charles Smallwood, M. D., L.L. D.,



Professor of Meteorology in the University of McGill College, Montreal. (Pamphlet.)

*Taylor, John.*—Mean temperature and amount of snow for each month and year at Connelville, Penn., from 1843 to 1855, and two miles east of Connelville, from 1856 to 1860.

*Volger, Ernest, U. S. Consul, Barcelona, Spain.*—Observations, with a full set of instruments, from September 1, 1858, to July 31, 1859, at Barcelona, Spain.

*Williams & Haven.*—Meteorological journal kept on board the whaling brig Georgiana, of New London, Conn., S. O. Buddington, master, from November, 1858, to June, 1859, in latitude  $63^{\circ} 20'$  N., longitude  $64^{\circ} 40'$  W.

## REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee respectfully submit to the Board of Regents the following report of the receipts and expenditures of the Smithsonian Institution during the year 1860, with estimates for the year 1861.

### RECEIPTS.

The whole amount of Smithson's bequest deposited in the Treasury of the United States, is \$519,169, from which an annual income, at six per cent. is derived, of..... \$30,910 14

The extra fund of unexpended income is invested as follows, viz :

In \$75,000 Indiana 5 per cent. bonds, yielding.....	\$3,750 00	
In \$53,500 Virginia 6 six per cent. bonds, yielding.....	3,210 00	
In \$12,000 Tennessee 6 per cent. bonds, yielding.....	720 00	
In \$500 Georgia 6 per cent. bonds, yielding.....	30 00	
In \$100 Washington 6 per cent. bonds, yielding.....	6 00	
		7,716 00

Total income..... 38,626 14

Balance in the hands of the Treasurer January 1, 1860, \$19,634 11, less the cost of \$5,000 Tennessee bonds, \$4,600 .....		15,034 11
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Total receipts..... 53,660 25

### EXPENDITURES.

For building, furniture, and fixtures.....	\$2,424 76	
For general expenses.....	13,079 34	
For publications, researches, and lectures....	13,852 99	
For library, museum, and gallery of art....	7,781 21	
		37,138 30

Balance in the hands of the treasurer January 11, 1861.		16,521 95
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*Statement in detail of the expenditures during the year 1860.*

## BUILDING, FURNITURE, AND FIXTURES.

Building incidentals.....	\$1,480 55
Furniture and fixtures in general.....	619 85
Furniture and fixtures for museum.....	324 36
	<hr/>
	2,424 76

## GENERAL EXPENSES.

Meetings of the Board.....	\$225 35
Lighting and heating.....	987 41
Postage.....	537 54
Transportation and exchanges.....	2,141 86
Stationery.....	393 50
General printing.....	206 18
Apparatus.....	784 78
Laboratory.....	150 81
Incidentals, general.....	755 94
Extra clerk hire.....	645 97
Salaries, secretary.....	3,500 00
chief clerk, book-keeper, messenger, and laborers.....	2,750 00
	<hr/>
	13,079 34

## PUBLICATIONS, RESEARCHES, AND LECTURES.

Smithsonian Contributions.....	\$5,520 59
Smithsonian Reports.....	770 22
Smithsonian Miscellaneous Collections.....	1,131 48
Other publications.....	45 89
Meteorology.....	4,431 07
Magnetic observatory.....	308 00
Researches and investigations.....	753 00
Lectures.....	892 74
	<hr/>
	13,852 99

## LIBRARY, MUSEUM, AND GALLERY OF ART.

Cost of books and binding.....	\$2,382 19
Pay of assistants in library.....	1,100 00
Transportation and exchange for library....	496 62
Incidentals for library.....	41 86
Museum, salary.....	2,000 00
Transportation for museum.....	872 76
Incidentals for museum.....	62 92
Explorations for museum.....	476 45
Collections for museum.....	111 23
Gallery of art.....	237 18
	<hr/>
	7,781 21
	<hr/>
	37,138 30
	<hr/> <hr/>

The accounts for the year 1860 were made up to the 11th of January, 1861, instead of the first of the same month as heretofore. This difference in time was occasioned by the delay in obtaining the appropriation and interest due at the beginning of the year.

The balance in the hands of the treasurer at the commencement of the year 1860 was \$19,634 11; of this, \$4,600 were expended in the purchase of \$5,000 Tennessee State bonds, leaving \$15,034 11.

The income during the year from the original and extra fund was \$38,626 14. The expenditures during 1860 were \$37,138 30; leaving \$1,487 84 to be added to the balance in the hands of the treasurer on the first of the year, making \$16,521 95 immediately available for paying in cash the expenses of the operations of the Institution as rapidly as the bills come due.

The foregoing statement is an actual exhibit of the Smithsonian funds, irrespective of credits and disbursements which have been made in behalf of other parties. For example: the Institution has frequently advanced money to pay for the transportation of packages for other establishments, such as the Coast Survey, Patent Office, &c., forwarded through the Smithsonian agents; and in all such cases the money, when refunded, has been credited to the appropriation from which the expenditure was originally made. Again: the use of the lecture-room has in many instances been granted for charitable purposes, without any other charge than for the gas consumed; and the money received for this has been credited on the books of the Institution to the account of "lighting and heating."

The agricultural department of the Patent Office has for several years past expended a small portion of its appropriation, for the collection of meteorological statistics in connection with this Institution. During the past year the assistance from this source has been unexpectedly very much reduced; and hence, the expenditure on meteorology from the Smithsonian fund has considerably exceeded the estimate.

The annual appropriation of \$4,000 from Congress, for keeping the collections of the exploring and surveying expeditions of the United States, has been expended under the direction of the Secretary of the Interior, in assisting to pay the extra expenses of assistants, and the cost of arranging and preserving the specimens. The aid thus rendered has served to diminish the cost to the Smithsonian fund of the maintenance and exhibition of the museum, although it has by no means been sufficient to defray all the expenses of these objects, as will be seen by reference to the items given under the head of the museum, in the detailed statement.

The specimens intrusted to the care of the Institution are in good condition, and the duplicates are in process of being assorted preparatory to a general distribution for scientific and educational purposes.

The committee respectfully submit the following estimates for the year 1861.

*Receipts.*

Balance in the hands of the Treasurer, January 11, 1861..	\$16,521 95
Interest on original fund .....	30,910 14
Interest on the extra fund.....	7,716 00
	<hr/>
Total.....	55,148 09
	<hr/> <hr/>

*Estimate of Expenditures for 1861.*

## BUILDING, FURNITURE, AND FIXTURES.

Incidentals .....	\$1,500 00
Furniture and fixtures.....	800 00
	<hr/>
	2,300 00

## GENERAL EXPENSES.

Meetings of the board.....	\$250 00
Lighting and heating.....	1,000 00
Postage .....	600 00
Transportation, (general).....	1,000 00
Exchanges .....	1,000 00
Stationery.....	300 00
General printing .....	300 00
Apparatus .....	800 00
Laboratory.....	150 00
Incidentals, (general) .....	600 00
Extra clerk hire .....	500 00
Salaries.—Secretary .....	3,500 00
Chief clerk, book-keeper, messenger, laborers, &c.....	3,000 00
	<hr/>
	13,000 00

## PUBLICATIONS, RESEARCHES, AND LECTURES.

Smithsonian Contributions.....	\$6,000 00
Smithsonian Reports.....	500 00
Smithsonian Miscellaneous Collections .....	1,000 00
Other publications.....	250 00
Meteorology .....	4,000 00
Magnetic observatory .....	250 00
Researches .....	400 00
Lectures .....	800 00
	<hr/>
	13,200 00

## LIBRARY, MUSEUM, AND GALLERY OF ART.

Library.—Cost of books and binding.....	\$2,500 00	
Pay of assistants in library.....	1,200 00	
Transportation and exchange for li- brary .....	500 00	
Incidentals.....	50 00	
Museum.—Salary.....	2,000 00	
Assistants and labor.....	1,000 00	
Transportation.....	550 00	
Incidentals.....	1,000 00	
Explorations.....	400 00	
Gallery of art.....	300 00	
		<hr/>
		\$9,500 00
		<hr/>
		38,000 00
		<hr/> <hr/>

The committee have carefully examined all the books and accounts of the Institution for the past year, and find them to be correct.

Respectfully submitted.

J. A. PEARCE,  
A. D. BACHE,  
JOS. G. TOTTEN,  
*Executive Committee.*

JOURNAL OF PROCEEDINGS  
OF THE  
BOARD OF REGENTS  
OF  
THE SMITHSONIAN INSTITUTION.

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WASHINGTON, *January 16, 1861.*

In accordance with a resolution of the Board of Regents of the Smithsonian Institution, fixing the time of the beginning of their annual session on the third Wednesday of January of each year, the Board met this day in the Regents' room.

No quorum being present, the Board adjourned to meet at the call of the Secretary.

FEBRUARY 16, 1861.

The Board of Regents met this day, at ten o'clock, a. m., in the Regents' room.

Present: Hon. James A. Pearce, Hon. James M. Mason, Hon. S. A. Douglas, Hon. W. H. English, Hon. Benj. Stanton, Gen. Jos. G. Totten, Prof. A. D. Bache, and the Secretary.

Mr. Mason was called to the chair.

The Secretary stated that there are at present three vacancies in the Board of Regents, among the class of citizens at large, namely: the vacancy occasioned by the expiration of the term of service of Hon. Gideon Hawley, of Albany, who declines a reelection on account of inability to attend; that occasioned by the death of Hon. Richard Rush; and that by the expiration of the term of Dr. C. C. Felton, of Harvard University: that a resolution was some time since presented to the Senate of the United States to fill these vacancies, which had not yet been acted upon.

Mr. Pearce presented the report of the Executive Committee, with the estimates for the year 1861; which was read and adopted.

A communication addressed to the Secretary, relative to the Wynn estate, was read.

The Secretary stated that since the death of Hon. Richard Rush, no communication had been received in regard to the remainder of the Smithsonian bequest left in England, as the principal of an annuity to the mother of the nephew of Smithson; whereupon, on motion of Mr. Bache, it was

*Resolved*, That the Secretary be requested to communicate with Messrs. Clark, Fynmore & Fladgate, attorneys in London, informing them of the death of Hon. Mr. Rush, and making inquiry as to the present condition of this annuity.

On motion of Mr. English, it was

*Resolved*, That the Secretary be directed to adjust the accounts of the Regents for traveling and other expenses, at each annual or special meeting, according to the provisions of the act of organization.

A letter was read relative to the debt of the State of Arkansas, desiring the Regents to unite with other parties in endeavoring to recover it.

The Secretary stated that he had replied, giving as his individual opinion that the Regents are in no way interested in this matter; the United States having assumed the debt originally due from the State of Arkansas to the Smithsonian fund.

On motion, it was

*Resolved*, That the Board concur in this opinion.

A communication addressed to the Board, from H. A. Gaston, of Napa City, California, requesting aid in introducing a new steam engine, was read.

The Secretary stated that this communication was one of a large class usually addressed to himself in his official capacity; that he had answered these communications by stating that it did not form a part of the policy of the Institution to give an opinion as to the merits of any invention, or to render assistance to any enterprise which, though it might be of importance to the public, was undertaken for the immediate benefit of an individual; that the government of the United States had enacted laws granting an exclusive monopoly to inventors as a reward for their ingenuity, and that they must apply to the Patent Office for the means of securing a remuneration for their labors. That if, however, in any case, an individual has made an invention for which he does not intend to take out a patent, then the Institution would accept, on the usual conditions, an account of such invention, and would make it known, through the Smithsonian publications, to the civilized world, thus securing to the inventor the *reputation* which might justly be his due.



The following memorial was presented from distinguished citizens of Philadelphia, accompanied by a letter from Mr. Lowe :

To PROF. JOSEPH HENRY,

*Secretary of the Smithsonian Institution, Washington, D. C.*

The undersigned, citizens of Philadelphia, have taken a deep interest in the attempt of Mr. T. S. C. Lowe to cross the Atlantic by aeronautic machinery, and have confidence that his extensive preparations to effect that object will add greatly to scientific knowledge. Mr. Lowe has individually spent much time and money in the enterprise, and, in addition, the citizens of Philadelphia have contributed several thousand dollars to further his efforts in demonstrating the feasibility of trans-Atlantic air navigation. With reliance upon Mr. Lowe and his plans, we cheerfully recommend him to the favorable consideration of the Smithsonian Institution, and trust such aid and advice will be furnished him by that distinguished body as may assist in the success of the attempt, in which we take a deep interest.

JNO. C. CRESSON.  
WILLIAM HAMILTON.  
W. H. HARRISON.  
HENRY SEYBERT.  
J. CHESTON MORRIS, M. D.  
ISAAC LEA.  
FAIRMAN ROGERS.  
JAMES C. FISHER, M. D.  
THOS. STEWARDSON, M. D.  
J. B. LIPPINCOTT.  
GEO. W. CHILDS.  
JOHN GRIGG.  
S. S. HALDEMAN.  
JOHN F. FRAZER.  
GEORGE HARDING.  
M. McMICHAEL.

PHILADELPHIA, *December, 1860.*

On motion of Mr. Mason, it was

*Resolved,* That the Secretary be requested to give Mr. Lowe any advice which he may deem fit, as to his experiments ; and to reply to the memorialists stating the reasons why the Regents do not consider themselves at liberty to make any appropriation from the Smithsonian fund for the purpose mentioned in the communication.

Several communications received by the Secretary from David P. Holton, were read and referred to the Executive Committee.

The following letters also were presented by the Secretary :

[Translation.]

BERLIN, *November 24, 1860.*

SIR: I have received the last invoice of publications, which through your kindness has been presented to me by your great and liberal

Institution. The grammar and dictionary of the Yoruba language, by Mr. Bowen, have especially interested me.

Expressing my thanks to the honorable directors, I have the pleasure to send some of my latest publications, with the request that they be placed in the Smithsonian library. They are the following:

1. Two volumes of my "Königsbuch," containing the chronological restitution of the Egyptian dynasties of Manethon, and the collection of the hieroglyphical names of all the kings; being, as it were, a supplement to the great work "On the Monuments of Egypt and Ethiopia," prepared by myself at the expense of the State, a copy of which the King, at my suggestion, has presented to the Smithsonian Library. Of this you have lately received the last series of plates, and the *descriptive text* will be sent as soon as I can finish it.

2. A dissertation, read at our Academy of Sciences, on the "Extent of the Egyptian History after Manethon."

3. Another similar one on several points of "Chronology."

4. A volume of thirty-seven plates, representing the pictures executed, under my direction, upon the walls of the Egyptian Museum, in Berlin.

To these I add some pamphlets relating to the introduction of a general linguistic or standard alphabet for expressing foreign languages, which have either not been written at all or not in European characters. They are, for the present:

5. An English copy of the pamphlet I have published on the standard alphabet.

6. A German copy of the same.

7. Translation, by Mr. Lechler, of the Gospel of St. Matthew into Chinese, in the characters of the standard alphabet.

8. Translation, by myself, of the Gospel of St. Mark, into the Nubian language; printed in types of the standard alphabet. This forms part of a book which also contains the grammar and dictionary of the Nubian and several other similar languages, the printing of which is not yet finished.

The two copies of the standard alphabet are of the first edition. We are just now printing the second, with some slight alterations and a much more complete collection of alphabets. I shall send it in time, and would not, at present, have transmitted the first edition, the small number of copies of which has actually been withdrawn, if it were not of special interest for a library to follow up the gradual development of a subject of general importance.

You will see from the pamphlet that most of the missionary societies have decided to introduce the alphabet, the American Board of Commissioners for Foreign Missions included, and that the number of books printed in these characters is rapidly augmenting. I know of sixty or more. I do not know whether you have any opportunity of exercising an influence among the savans of your country in favor of the adoption of the standard alphabet. At any rate you will allow me to recommend such a course. Mr. Bowen, from his Yoruba grammar, seems not to have had any knowledge of it; while Mr. Crouther, his learned predecessor in the grammar of this language, has already adopted it in his later publications; and Mr. L. Grout,

also of the American Board, has made use of and has earnestly recommended it in his excellent grammar of the Zulu-Kaffir.

I should feel very grateful, if you will let me know whether there has been any attention given to this question with you, and if you would communicate to me whatever may relate to the subject. The original languages of America will be found transcribed in much greater number in the second edition of the standard alphabet; and, if you know of any scholar who makes the study of these languages his specially, and who could give me instructions as to the exact pronunciation of the letters of some of them, I would be much obliged if you would make me acquainted with him.

Among your former publications, besides those relating to linguistics and ethnology, such as the grammar of the Dakotah language, there are also memoirs relating to the antiquities of different parts of America, viz: the researches of Squier and Davis on the monuments of the Mississippi. I received from Mr. Squier himself his memoir on the monuments of New York, (vol. II, art. 9;) and also have most of the writings of Squier, Pickering, and Morton, in separate publications; but of your antiquarian publications I am still in want of the following: Vol. I; vol. II, art. 2; III, 6, 7; VII, 5. I do not venture to designate other memoirs that would gratify my general interest in American science; yet I should be highly obliged if you would continue the transmission of your reports, and add those of the foregoing volumes which you can most readily spare.

Will you let me know whether you have already the first volume of my "Egyptian Chronology;" if not, I shall not fail to send a copy.

I beg your pardon for this long letter, which I fear has taken too much of your time, occupied by many other subjects.

Accept the expression of the high consideration with which I am, sir, your most obedient,

R. LEPSIUS.

Professor JOSEPH HENRY,

*Secretary of the Smithsonian Institution.*

MELBOURNE BOTANIC AND ZOÖLOGIC GARDEN,  
October 25, 1860.

HONORED AND DEAR SIR: I owe you my grateful acknowledgment of transmitting to me, through the kindness of Hon. William Haines, the valuable reports of the Smithsonian Institution for 1857 and 1858, and the celebrated work on the North American algae, furnished by our common friend Dr. Harvey.

Whilst expressing my warmest thanks for having been deemed worthy, by your noble Institution, to share in the gifts which, by the world-famed liberality of the Smithsonian Institution, the men of science so extensively enjoy, I beg to state that it will be a source of pleasure to me to endeavor to reciprocate your friendly offers, and that I hope, through Prof. Asa Gray, within a few months, to lay several recent publications of mine, including the first volume of the "Plants of Victoria," before your Institution and other American scientific associations.

If I can in any way serve the laudable purposes of your excellent Institution, I hope you will freely command my services.

Most regardfully, dear Professor Henry, yours,  
FERD. MUELLER.

The Secretary gave an account of what has been done in relation to the distribution of duplicate specimens of natural history, and read several letters acknowledging the receipt of the donations, and expressing appreciation of the policy adopted by the Institution. Among these was the following:

UNIVERSITY OF TORONTO,  
December 3, 1860.

DEAR SIR: In acknowledging the receipt of about 200 species of shells sent to the University Museum, through the liberality of the Regents of the Smithsonian Institution, I beg to express my very high appreciation of the disposition manifested by the Institution to make its superfluous stores available in the communication of knowledge in various places, and even beyond the limits of the United States. The contribution now made is a very valuable addition to the museum of the University of Toronto, even those species of which we have already specimens being interesting from their authentic names and known habitats.... We are deeply obliged by the kindness manifested; and if we find any way of reciprocating it, I shall personally feel the greatest pleasure in promoting your views.

Believe me to be, dear sir, very faithfully yours,  
WILLIAM HINCKS.

The SECRETARY OF THE SMITHSONIAN INSTITUTION.

Copies of the several papers and miscellaneous articles published by the Institution since the last annual session were laid before the Board.

The fact was stated that the Potomac water had been brought by Government through the grounds of the Smithsonian Institution, to the middle of the south front of the building; that the Institution was now supplied with rain water from the cisterns in the towers, but as the supply from this source was uncertain, it was desirable that the Potomac water should be introduced; whereupon it was

*Resolved*, That the Secretary procure plans and estimates for the introduction of the Potomac water into the building, and that the Secretary and the Executive Committee be authorized to make contracts for this purpose.

The Secretary presented his annual report of the operations of the Institution; which was read in part.

The Board then adjourned, to meet on Tuesday, February 19, at 8 o'clock p. m.

TUESDAY, *February* 19, 1861.

The Board met at 8 o'clock p. m., in the Regent's room of the Smithsonian Institution.

Present: Hon. James M. Mason, Hon. W. H. English, Hon. B. Stanton, General Joseph G. Totten, Professor A. D. Bache, and the Secretary.

Mr. Mason was called to the chair.

The minutes were read and approved.

The report of the Secretary was read and adopted.

The Board then took a recess till Friday evening.

FRIDAY, *February 22, 8 p. m.*

Present: Messrs. Pearce, Douglas, English, and Totten.

The Secretary read the appendix to his annual report.

The Secretary presented the following letters, which he had prepared in accordance with the resolution of the Board, relative to aerial navigation, in answer to the memorial of citizens of Philadelphia, and to the communication of Mr. Lowe.

SMITHSONIAN INSTITUTION,  
*Washington, March 8, 1861.*

GENTLEMEN: Your communication, addressed to the Smithsonian Institution, commending Mr. Lowe to the Board of Regents, for assistance in carrying out his proposed experiment to cross the Atlantic by means of a balloon, was duly received. It was presented to the Board of Regents at their meeting of February 16, was respectfully considered, and, after due deliberation, the following resolution was adopted:

*“Resolved, That the Secretary be requested to give Mr. Lowe any advice which he may deem fit as to his experiments; and to reply to the memorialists, stating the reasons why the Regents do not consider themselves at liberty to make any appropriation from the Smithsonian fund for the purpose mentioned in the communication”*

In accordance with the above resolution I would state that the Board of Regents of the Smithsonian Institution are responsible to the Government and to the world for the prudent expenditure of the income of the Smithson bequest, and inasmuch as the proposed experiment is one which, in the minds of the majority of considerate and reflective persons, is of great hazard, the Regents do not think, whatever might be their individual desire to advance the art of aerial navigation, that they would be justified in making an appropriation from the Smithsonian income to assist in this enterprise.

Any questions which may be propounded to me in regard to the experiment of Mr. Lowe will be cheerfully answered, as far as we have the means of giving the required information.

I have the honor to be, very respectfully, your obedient servant,

JOSEPH HENRY,  
*Secretary Smithsonian Institution.*

To Messrs. JNO. C. CRESSON, ISAAC LEA, and others,  
*Philadelphia.*

SMITHSONIAN INSTITUTION,  
*Washington, D. C., March 11, 1861.*

DEAR SIR: In reply to your letter of February 25, requesting that I would give you my views in regard to the currents of the atmosphere and the possibility of an application of a knowledge of them to aerial navigation, I present you with the following statement, to be used as you may think fit.

I have never had faith in any of the plans proposed for navigating the atmosphere by artificial propulsion, or for steering a balloon in a direction different from that of the current in which the vehicle is floating.

The resistance to a current of air offered by several thousand feet of surface, is far too great to be overcome by any motive power at present known which can be applied by machinery of sufficient lightness.

The only method of aerial navigation which in the present state of knowledge appears to afford any possibility of practical application, is that of sailing with the currents of the atmosphere. The question, therefore, occurs as to whether the aerial currents of the earth are of such a character that they can be rendered subservient to aerial locomotion.

In answering this question, I think I hazard little in asserting that the great currents of the atmosphere have been sufficiently studied, to enable us to say with certainty that they follow definite courses, and that they may be rendered subservient to aerial navigation, provided the balloon itself can be so improved as to render it a safe vehicle of locomotion.

It has been established by observations extending now over two hundred years, that, at the surface of the earth, within the tropics, there is a belt along which the wind constantly blows from an easterly direction; and, from the combined meteorological observations made in different parts of the world within the last few years, that north of this belt, between the latitudes of  $30^{\circ}$  and  $60^{\circ}$ , around the whole earth the resultant wind is from a westerly direction.

The primary motive power which gives rise to these currents is the constant heating of the air in the equatorial, and the cooling of it in and toward the polar regions; the eastern and western deflections of these currents being due to the rotation of the earth on its axis.

The easterly current in the equatorial regions is always at the surface, and has long been known as the trade winds, while the current from the west is constantly flowing in the upper portion of the atmosphere, and only reaches the surface of the earth at intervals generally after the occurrence of a storm.

Although the wind, even at the surface, over the United States and around the whole earth between the same parallels, appears to be exceedingly fitful; yet when the average movement is accurately recorded for a number of years, it is found that a large resultant remains of a westerly current. This is well established by the fact that on an average of many years, packet ships sailing from New York to Great Britain occupy nearly double the time in returning that they do in going.

It has been fully established by continuous observations collected at

this Institution for ten years, from every part of the United States, that, as a general rule, all the meteorological phenomena advance from west to east, and that the higher clouds always move eastwardly. We are therefore, from abundant observation, as well as from theoretical considerations, enabled to state with confidence that on a given day, whatever may be the direction of the wind at the surface of the earth, a balloon elevated sufficiently high, would be carried easterly by the prevailing current in the upper or rather middle region of the atmosphere.

I do not hesitate, therefore, to say, that provided a balloon can be constructed of sufficient size, and of sufficient impermeability to gas, in order that it may maintain a high elevation for a sufficient length of time, it would be wafted across the Atlantic. I would not, however, advise that the first experiment of this character be made across the ocean, but that the feasibility of the project should be thoroughly tested, and experience accumulated by voyages over the interior of our continent. It is true that more eclat might be given to the enterprise, and more interest excited in the public mind generally, by the immediate attempt of a passage to Europe; but I do not think the sober sense of the more intelligent part of the community would be in favor of this plan; on the contrary, it would be considered a premature and foolhardy risk of life.

It is not in human sagacity to foresee, prior to experience, what simple occurrence, or what neglect in an arrangement, may interfere with the result of an experiment; and therefore I think it will be impossible for you to secure the full confidence of those who are best able to render you assistance except by a practical demonstration, in the form of successful voyages from some of the interior cities of the continent to the seaboard.

Very respectfully, your obedient servant,

JOSEPH HENRY,

*Secretary Smithsonian Institution.*

T. S. C. LOWE, Esq.,  
*Philadelphia, Pa.*

The Board then adjourned *sine die*.

The first part of the book is devoted to a general history of the United States from its discovery to the present time. It is written in a simple and plain style, and is intended for the use of schools and families. The author has endeavored to give a full and accurate account of the principal events of our history, and to show the progress of our country from a remote and obscure spot to a great and powerful nation.

The second part of the book is devoted to a detailed history of the United States from the year 1776 to the present time. It is written in a more elaborate style, and is intended for the use of those who wish to know more of our history. The author has endeavored to give a full and accurate account of the principal events of our history, and to show the progress of our country from a remote and obscure spot to a great and powerful nation.

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GENERAL APPENDIX

TO THE

REPORT FOR 1860.

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The object of this Appendix is to illustrate the operations of the Institution by the reports of lectures and extracts from correspondence, as well as to furnish information of a character suited especially to the meteorological observers and other persons interested in the promotion of knowledge.

# LECTURES.

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## ON ROADS AND BRIDGES.

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BY FAIRMAN ROGERS,  
PROFESSOR OF CIVIL ENGINEERING IN THE UNIVERSITY OF PENNSYLVANIA.

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### FIRST LECTURE.

It is the business of the civil engineer to design and to execute the public works of a country, and of such works the means of communication are, perhaps, the most important. In some countries this branch of the engineer's profession is taken as a type of the whole range of his duties; and we find in France the "*Corps des Ponts et Chaussées*" is not confined necessarily to the consideration of "bridges and roads" only, but extended to the many branches which we include under the name of "civil engineering."

I shall devote these lectures to an examination of the principles which govern the location and construction of roads, and of the bridges, which, under ordinary circumstances, form an important part of them.

In any country, no matter how new, means of communication between different settlements of men, or between any points of resort, are of the first necessity. Where all traveling is done on foot, as was the case in our country while occupied by the Indians, simple trails marked by blazed trees to indicate the direction, will be sufficient. When beasts of burden are introduced, a wider and smoother path is necessary, and road making on a small scale commences; obstacles which the hunter on foot easily surmounted must be removed for the pack horse. In many rough countries, such as Switzerland and Spain, bridle paths were the only avenues of communication until within a very recent period, and many of these are in use at the present day. In very mountainous countries, even the construction of a bridle path requires a considerable amount of labor and ingenuity, as is shown in most of the Swiss passes—such as that of the St. Bernard, the Tête Noire, and particularly the Gemmi.

As sledges or wheeled vehicles, even of the rudest description, come into use, the roads must be made wider, smoother, and less steep, until we come to the limits which are now assigned by engineers for roads of the first class.

It would seem hardly necessary to dilate upon the immense advantages which spring from ample and economical means of communication throughout a country. In this age of rapid locomotion, they are

strongly set forth in the prospectus of every new railroad project, and are familiar to all; but, somewhat strangely, while we have covered our country with these iron ways, we have the doubtful honor of having the very worst common roads of any civilized country on the globe. This is probably owing to two reasons: first, that the railroads which were introduced just at the time when our public improvements were being projected, naturally absorbed all attention to the exclusion of other means of communication; and secondly, that there has been a lamentable deficiency of the information and education necessary to insure the successful location and construction of common roads among those to whom they have been intrusted.

In Europe, where perfect roads were needed long before the iron way was invented, an amount of money and thought had been expended in making roads which strikes the American traveler with astonishment. He finds that as much labor and care have been bestowed upon common roads in the old world as have been by us upon our railroads.

It is much to be hoped that as the necessary information is diffused throughout the country, our common roads will improve in condition, especially since, in many cases, such improvement is attended with economy in first cost, in working, and in maintenance, and will only require a little more expenditure of thought and care in the planning and execution.

The principles involved in the location and construction of roads are few, simple, and unchangeable; and a little attention paid to them by road makers would prevent the mistakes which are so painfully apparent to every traveler.

The subject of road making is divided into two parts: *location and construction*; the art of locating a road being that of determining and tracing on the ground the *best* line for the road to follow—of construction, that of preparing the road bed for the traffic which is to pass over it.

In the very simplest case that can be imagined, that of a foot path to connect two places situated on a smooth plain, no location would be necessary beyond marking the path in some way, so that the direction could be kept by the traveler; but such a very simple case could rarely occur, and as the difficulties increase we must find means to overcome them.

As a general rule, a foot path may be led over almost any obstacle; for an experienced mountaineer can ascend nearly perpendicular cliffs, especially when aided by even the most simple appliances, such as ladders, ropes, or notched logs. The famous "*Path of Ladders*" at the Baths of Loesche, in Switzerland, is an example of a foot path of the rudest description. These baths are situated in a deep valley surrounded with perpendicular cliffs, and the only way by which they can be reached is by passing almost perpendicularly down the cliff by means of ladders fastened to the face of the rock.

Since we rarely find a plain, but usually a surface more or less undulating, we must be able to locate our road to the best advantage upon it. Although upon the map a straight line between two points seems to be the shortest, we shall find, when we come to examine it

upon the ground, that it is not always so, for it may pass over so many elevations and depressions that it is actually longer than a line traced near it and avoiding these irregularities.

If we have a hill of a hemispherical form, like half of a globe, placed upon a table, the distance from one side to the other over the top will be *precisely* the same as the distance around it at its base, and we should have the disadvantage of going up on one side and down on the other, instead of keeping a level road around.

Although this principle seems a simple one, we find it continually disregarded, there being frequent cases where common roads pass directly over a high point with lower ground within a few feet on either side of them. In fact, in any country other than a perfectly level one, a road which keeps a straight direction for mile after mile, as many of our turnpikes do, must necessarily be badly located, since advantage has evidently not been taken of the natural features of the surface.

We must bear in mind the fact that the force required to draw a well made wagon in good order over a smooth level road is very small compared with the absolute weight of the wagon and load. On a good turnpike about one fiftieth of the load,\* that is a tractive force of ten pounds will move a load of five hundred pounds, the only resistance being from friction of the axles and from the minute obstacles of the surface. Under such circumstances, the horse's power is applied most economically.

When a horse attempts to move a load up an inclined plane, however, in addition to overcoming the friction, he has also to raise a part of the weight of the wagon, according as the inclination is more or less great. Now, if the two places connected by the road are on the same level, all lifting of the load up inclinations only to let it down again on the other side will be so much power expended uselessly. Increasing the length of a road, therefore, to avoid hills, is in most cases an economy to the traveler. Of course, the exact amount of increase, or the equation of grades and distances, as it is called by the engineer, must be a matter of calculation based upon experiment and observation.

A considerable deviation can be made to the right or left of a straight line joining two points without materially increasing the length of the road. For example: if the two points be ten miles apart; we may deviate a whole mile at the middle of the distance, to either side, without increasing the length of the path traveled the fifth of a mile.

Having these general principles to guide him, the engineer, in locating a road, should first make a thorough examination, on foot or on horseback, of the whole country lying between the points to be connected. He should collect all the maps of the region that he can find, and he should gather from the inhabitants information on various subjects: such as, where low places exist in the ridges; what points are particularly free from, or filled up with, snow in the winter; what places are remarkably exposed to the wind; and particularly ascertain the height and boundaries of all the streams during the highest freshets that have been known, so that no part of the road or bridges may be exposed to danger from a rise of the water. In a rather small region,

\* Poncelet. Morin.

with decided leading features, the experienced engineer will often be enabled, after a thorough *reconnoissance* of this kind, to determine within narrow limits upon the location; but in an extended and difficult or broken country, it will often be necessary to make a survey of several trial lines before a sufficient amount of information can be collected.

In the United States, where, except along the sea-coast and in Massachusetts, no regular and reliable general surveys have been made, the maps will be found quite deficient, and in many cases the engineer must prepare one more or less extended for his own use. This will be particularly the case in a rough mountain country, where much time would be lost in making the surveys of trial lines, many of which would turn out to be impracticable when nearly completed.

Much information can be gained even from a map which has only the streams marked upon it. Since the stream always runs through the lowest line of the valley, the position of the valleys and the general inclinations of the country will be indicated by them. A very crooked stream, with softly rounded bends, will almost always indicate a smooth, nearly level, alluvial bottom or meadow land through which it flows; while straight streams, with sharp angles, and with branches running abruptly into them at large angles, indicate a rocky, hilly country, with narrow, steep-sided valleys. These indications are, however, so very general that a map, showing the different heights of the various points of the country, is absolutely essential. Such a map is called a topographical map.

There are two methods in use of delineating upon paper the topographical features of a country—by *hachure lines* and by *contour lines*. The first and older system indicates the inclinations by short lines drawn in the direction of the slope of the ground, and the amount of the inclination by the greater or less thickness of the lines, in accordance with some arbitrary standard. In the second system, the relative heights of the various points are indicated by continuous lines of equal level, at certain vertical distances apart. The first originated with, and is especially adapted to the wants of, the military engineer, since the *inclination* of the surface is the matter which most concerns him; the disadvantage of it, however, is, that it conveys but a faint idea of the true features of the surface, even to the expert. Figs. 1 and 2 show the two methods applied to the same surface.

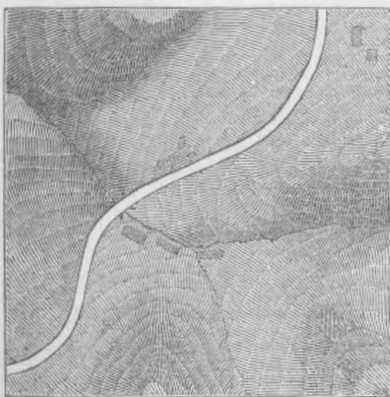


Fig. 1.

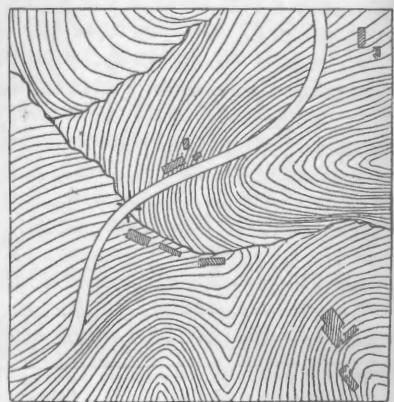


Fig. 2.

The method of contour lines will be readily understood from the following explanation. Let us suppose an island situated in a lake: the water will wash the base and form a water line, all the points of which will be in the same horizontal plane—that is, on a level with the surface of the lake. Now, if we suppose the water to rise one foot, another water line will be made, all the points of which will be in a horizontal plane one foot above the first plane, all the points of the surface of the island between these two lines will be less than one foot above the level of the lake. By successive stages of the water we shall get a succession of lines, until the island is entirely submerged. Now, suppose we place ourselves in a balloon above the island, and look down upon it as upon a map, we shall see all these horizontal curves projected upon the level surface, as in Fig. 3.

And if we make a map of the island, with these lines upon it, our topographical information regarding it will be complete. Knowing the vertical distance between the lines, by measuring the horizontal distance we can determine the inclination. The elevation of any point may be determined by simple inspection. With a map of this kind carefully prepared, the engineer can locate his line in the office, and often to greater advantage than in the field—since he can see the whole country at a glance. Having thus a general map of the country, he will be guided by a few simple principles.

If a ridge exists between the points to be connected, it is usually desirable to cross it at its lowest point. A stream commonly starts from such a point, and by following it up, the summit can be reached by a comparatively easy ascent along the valley. The most difficult countries are those which have no leading streams or valleys, but which are broken up by rounded hills and disconnected hollows—since a line which appears practicable for a considerable distance will sometimes end in an impracticable spot. In such regions, a carefully-constructed topographical map is indispensable to prevent the expenditure of a great deal of time in wild explorations.

It should be distinctly borne in mind that a reconnaissance sufficiently accurate for the purpose, can be made in a comparatively short time, by an experienced topographer, with a very small party and portable instruments; while the running of trial lines is a much more serious matter. In an ordinarily level country, the attention of the engineer will be turned to the selection of the best route, without his ingenuity being taxed to surmount great obstacles; and he will therefore aim at making the road as direct as possible, while avoiding any great ascents or descents.

In an extremely mountainous country like Switzerland, it will sometimes be difficult not only to obtain the best line, but to find *any* line which will be practicable, owing to the great difference of level of the

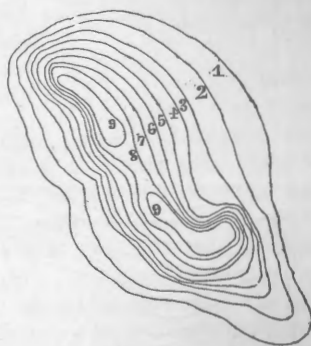


Fig. 3.

points to be connected. And this brings us to the consideration of the important subject of grade.

I have stated that the force required to move a load on a level bears but a small proportion to the whole weight; but that on an inclined plane, the animal drawing the load must lift it vertically through a distance which depends upon the inclination. Careful experiments have shown that in a first-class mountain road the grade should not exceed one in thirteen—that is, a rise of one foot in every thirteen feet of horizontal distance, and that even this grade should be used only on short sections, and should be varied by frequent levels on which teams may rest. Now, if the difference of height between any two points is more than one thirteenth of the horizontal distance, it will evidently be impossible to connect them by a straight road, since it will be too steep. The horizontal distance must be increased while the vertical distance remains the same. In cases where the points are at the extremities of a straight, narrow valley with precipitous sides, as is frequently found in the Alps, considerable difficulty will be encountered in getting this increased length, and the ingenuity of the engineer will be severely taxed.

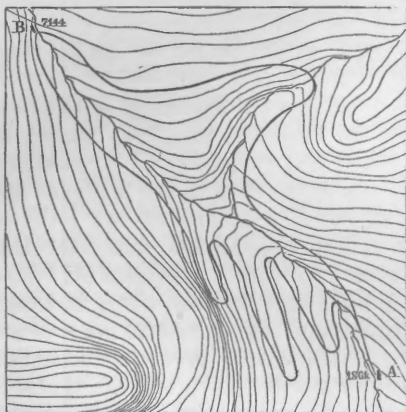


Fig. 4.

In Fig. 4., we have two points, A and B, ten miles apart, horizontally situated in the same straight valley, and B 5,280 feet above A, A having an elevation of 1,864 feet above the sea, and B 7,144 feet, a road ten miles long connecting them would have a grade of one in ten, which is too steep. The length of the line must, therefore, be increased. This may be done by running up the valley of the stream to the northwest, as indicated by the dotted line ..... A C B, or by turning the line upon itself in a series of zig-zags on the slope of the hill on the other side,

as shown by the continuous line A D B. Both of these expedients are frequently resorted to. Of course, where there is a valley up which the road can be taken according to the first method, it should be taken advantage of, since the sharp turns of the zig-zags are thereby avoided.

On the mountain roads of Switzerland, there are many interesting examples of these zig-zags or *lacets*, (lacings,) as they are called by the French engineers. Frequently, on the steep side of a valley there is no other way of overcoming the ascent, and they must be resorted to. On the Italian side of the Splügen Pass, the road winds in this way down the almost vertical side of the mountain above the little village of Isella, and the carriage descends rapidly, turning the corners at the end of the zig-zags and swinging backwards and forwards over the valley.

On the St. Gothard Pass also, on the Italian side, above the village of Airolo, the road leaves the main valley and runs in the same way up



its steep side, crossing in a depression on the top on to a higher ridge, so that, while the carriage winds slowly up the heavy grade, the nimble pedestrian can scramble up the hill from angle to angle of the road and reach the top much sooner.

“O'er the Simplon, o'er the Splügen winds  
 A path of pleasure. Like a silver zone,  
 Hung about carelessly, it shines afar,  
 Catching the eye in many a broken link,  
 In many a turn and traverse as it glides;  
 And oft above and oft below appears,  
 Seen o'er the wall by him who journeys up,  
 As if it were another, through the wild  
 Leading along he knows not whence or whither;  
 Yet, though its fairy course go where it will,  
 The torrent stops it not; the rugged rock  
 Opens and lets it in, and on it runs,  
 Winding its easy way from clime to clime,  
 Through glens locked up before.”\*

The carriage roads of Switzerland are extremely interesting from the great difficulties which were frequently met in their location, and from the ingenuity with which these difficulties have been overcome, to say nothing of picturesque and in many cases wild scenery by which they are surrounded.

The Simplon, built by Napoleon in 1800—1806, M. Ceard chief engineer, is the oldest and the most famous of these roads. The length of the mountain division of it, between Brieg and Domo d'Ossola, is about forty-eight miles, and in this distance there are 611 stone bridges, ten galleries or tunnels, some cut out of the solid rock and others built of masonry, to protect the road against avalanches, besides the retaining walls and other necessary structures along the line. It has a width of twenty-five to thirty feet, a maximum grade of one in twelve, and cost about \$25,000 per mile. At one time more than 30,000 men were engaged upon it at the same time. Mont Caris, by the Chevalier Fabbroni; the Splügen, by Donegani; the St. Gothard, by Müller; the Bernadin, by Pocobelli; the Stelvie, by Donegani, are all of the same class of roads and are highly interesting to the student of engineering. Their summits are all more than 6,500 feet above the sea. In this country a very interesting road is now being constructed up one of the flanks of Mount Washington, in New Hampshire. It starts from the Glen House and keeps a nearly regular grade, with here and there short levels for resting the horses. It winds up the side of the mountain without encountering any great difficulties, and will, when finished, afford an easy carriage route to the summit, an elevation of more than 6,000 feet above the sea.

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\*Rogers' Italy.

## SECOND LECTURE.

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### CONSTRUCTION OF ROADS.

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Having examined briefly the principles which govern the engineer in determining the general line of a road, we shall now consider the rules to be followed in the construction.

In the first place a regular cross section of the road bed is important, with a smooth hard surface, and sufficient width to accommodate the traffic expected.

In a new, sparsely settled country, the road should be quite narrow, since it is then much more easily kept in repair; a width of sixteen or eighteen feet is quite sufficient. Near large cities roads should have a width of fifty to sixty feet, or even more. The surface must be such as will remain smooth, and not be easily affected by the weather. If, as is usually the case in new countries, we make use of the material found on the spot, for the road, such as clay, gravel, &c., we may make a very good road by paying strict attention to the drainage. In fact water or dampness is the great enemy of the engineer; it acts in the destruction of the road in three ways. In large quantities, as during heavy rains, it washes the surface of the road into gullies, and undermining the banks causes serious and expensive accidents. In smaller quantities it percolates into the material, and converts the earth into a pasty mud, which yields to the horses feet and to the wheels, and sometimes slips out of place, so that an embankment will melt away into a shapeless mound. In winter it freezes and throws up the earth which has been soaked with it to the destruction of the surface of the road.

Drainage is then one of the first objects of the engineer. The surface water must be carefully and quickly led away by ample ditches on each side of the road, which turn it into the natural water courses, or discharge it where it can do no harm.

These same ditches, when properly placed, and sometimes aided by secondary ones, or by drains, will serve to keep the whole mass of material dry, and prevent accident from the two other causes mentioned.

Almost any material will make a good road if it is properly drained; all will give trouble if drainage is not attended to. Sand, as we find it in the neighborhood of the sea, is, to a certain extent, an exception to this rule.

Every precaution must be taken, therefore, to carry off the water which falls upon the surface. To effect this the road should be slightly sloped transversely from the center each way to throw the water into the ditches.

The old method was to *crown* the roadway; that is, to give it a curved section, as shown in Fig. 5, but this is found to be objectionable from the fact that vehicles, in order to avoid the sloping sides, keep in the middle of the road, and cut it rapidly into ruts; it is preferred, therefore, to make the cross section with two slopes meeting in the middle, as in Fig. 6, the point being slightly rounded off. In this way the same difference of level between the center and sides may be made, and the inclination near the side will not be as great as by the old method.\*



Fig. 5.

the middle, as in Fig. 6, the

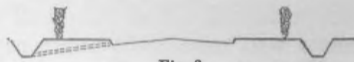


Fig. 6.

The general cross section is shown by these figures. In Fig. 5 the ditches or gutters are between the road and the foot paths. There are two objections to this; if the ditch is at all deep, there is some danger of overturning a carriage if the wheel is driven into it, and it is difficult to cross from the foot walk.

A better arrangement is shown in Fig. 6, where the ditches are on the outside of the fence or hedge, and the water which falls upon the surface of the road runs into them by drains passing under the foot path.

In a new country where much labor cannot be spent upon the roads it is sufficient to dig two ditches, about eighteen feet apart, and throw up the earth between them to make the road, taking care to cut off the sod and grub up the bushes from the surface, before laying the earth upon it, so that it may bind well, and not be in danger of slipping into the ditch.

When the road is higher than the land around it, there is no difficulty in draining it, but when it is below the general level, more provision must be made for carrying off the water; the excavation must be made of sufficient width to contain the road and its two ditches, as shown in Fig. 7; and the road must not be made to serve the purpose of a ditch itself, as is frequently the case—Fig. 8.



Fig. 7.



Fig. 8.

If the excavation is very deep, the road may be made rather more narrow at that point. The bottom of the ditches should be at least two feet below the roadway, may be lined with stone, if convenient, and should be kept clean.

Stiff clay soils that retain the water, require the most careful drainage; gravel and sand are more easily kept in order, since the water percolates freely through them.

\*This slope should be about one fifth of an inch to the foot. It is a mistake to make it much greater.

On a hillside the road should not be crowned, since the water would then run down the slope, and cut it away; but it should have an inclination *towards* the hill, as shown in Fig. 9; the ditch should be on the inside, and the water should be led from it by drains *under* the road, at proper intervals. Where there is a choice between the north and south side of a hill or ridge, the south should

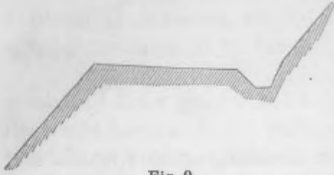


Fig. 9.

be preferred, since the road will then dry more quickly, and ice and snow will melt away more rapidly.

With the view of exposing the road to the action of the sun, some engineers have opposed the planting of trees along the sides; but the difference in the pleasure and comfort of the traveler, especially in warm climates, is so very great, that a fine row of trees, at least on the south side of a road, must be considered an important addition to it.

Such planting may be readily and cheaply done when the road is first built; and if the proper trees be selected, the expenditure will be amply repaid. In winter, when the action of the sun is desired, the leaves will be off, and deciduous trees should therefore be used; and in the summer the shade is grateful, and serves to prevent, to some extent, the formation of dust, by keeping the surface slightly damp and breaking the force of the wind.

On all roads footpaths of some kind should be prepared; and near large cities and through villages they should be on both sides of the road, and should be wide, hard, and smooth. It is a great outrage that turnpike and plank-road companies should be permitted to occupy public routes, and not be required to provide suitable accommodation for pedestrians.

So far we have considered only the way to make a good road of the natural soil of the place, but sometimes the very bad material, or the desire to have a superior road, will induce us to resort to additional means of improvement.

For a road covering, we want something which shall make a firm, hard, lasting, but not slippery surface. If it is yielding like India rubber, notwithstanding it may come back to its form after the load has passed over it, its resistance to traction will be considerable, since the wheel will be always in a hollow or depression caused by the weight upon it, out of which it must be lifted. It must be hard, so that it cannot readily be cut into ruts or displaced, but there must be no danger that the animals drawing loads will slip upon it.

Loose sand makes one of the worst roads in dry weather; the wheel displaces it, and is constantly moving in a deep rut with the sand closing over it; the horse, too, becomes much fatigued by sinking into the yielding material.

On the sea-beach, where the sand is constantly wet from the rise of the tide and the capillary rise of the water between the particles, this same material makes the best road with which we are acquainted, perfectly smooth, level, with no obstacle of the size of a pea, so hard that the wheels and the horses' feet scarcely make a mark on it, and yet not in the slightest degree slippery; but such cases are exceptional,

and we must take such roads where we find them ; we cannot make them.

A clay road, although good for certain short seasons, is usually intolerably dusty in summer and soft and muddy in winter ; consequently objectionable.

There are also certain swampy, soft soils, over which road building is attended with great difficulties. On the other hand, a road through a gravelly soil, if well drained, generally is sufficiently good ; and there are certain hard clay slates and shales which make roads of the very best character. When, therefore, we are called upon to improve a road by covering it with some material, we may select gravel, slate, cinder, charcoal, or broken stone.

Gravel for this purpose should be neither very clean nor too dirty ; if the former, it will not pack or bind together, but will remain loose and incoherent ; if the latter, it will not drain properly, and will be affected by moisture and frost. The stone should be angular, rather than round. Slate, furnace cinder, and charcoal can only be procured in certain localities, and the last is objectionable from the black dust which arises from it ; they are all, however, admirable materials, and can be often used with great advantage.

Broken stone, which can be had in nearly all localities, is, however, the material most commonly in use. It should be hard, so that the angles of the fragments should not be ground off by the wheels ; the close-grained limestones and most of the porphyritic rocks being well adapted to the purpose. Any stone which is disintegrated by exposure to the weather, should be carefully avoided. The stone should be broken into pieces of such a size that they will pass through a ring two and a half inches in diameter, and as nearly of the same dimensions as possible, uniformity being of great importance.

The road having been properly graded, with a slope to both sides as before described, the broken stone must be laid upon it to a depth of from ten to twenty inches, watered a little if the weather is dry, and the traffic of the road permitted to come upon it. It should be kept clean, the practice of scattering earth over the surface being especially pernicious, since it prevents the stones from binding well together. A better and quicker method of causing the stones to bind together is to roll the road with a heavy iron roller, but of course it is more troublesome and expensive than merely permitting the travel to do it.

In the neighborhood of cities especially, where there is much pleasure travel, it may sometimes be a good plan to stone the middle of the road only for a width of about sixteen feet, and leave a soft summer road of clay on each side.

The preparation of the road bed to receive this coating of broken stone, has been the subject of discussion between two eminent road-makers in England—Telford and McAdam—and opinion is still divided between the two systems proposed by them, although that of the latter, having the advantage of less first cost, has been most generally adopted.

Telford, the engineer of the Holyhead road, thought that the stone should be laid upon a rigid foundation, and he therefore paved his road bed with thin stones set on edge, and laid the covering on that, con-

sidering that the stones would not in that case be forced out of place into a yielding surface below.

McAdam, on the contrary, contended that the road covering thus placed between the wheels and the unyielding pavement would be rapidly ground to pieces, and that an elastic substratum is necessary to prevent such an action; he, consequently, laid his road covering upon the natural soil. Experience has not shown any great difference in practice, although where first cost is no object, the Telford method is perhaps somewhat preferable.

On all stone roads careful attention must be paid to the repairs. The usual way in this country of letting a road get into a bad condition, and then undertaking general repairs, being much to be condemned. The only proper way of keeping a road in good order is by a system of *constant* repairs; the moment that a rut or a depression is observed, the stones in and around it should be *loosened* with a pick, and enough fresh stone should be put into it to bring it slightly above the proper level, the traffic soon smoothing it down. It is absurd to attempt to mend a road by pouring stone into a deep hollow with smooth hard sides, the stones having nothing to bind to; and when they become wet, they grind each other under the wheels into round pebbles, which never can be made to hold together.

No loose stones should be permitted to remain on the surface, where they are exceedingly mischievous, but they should be either promptly put back into the holes from which they came, or thrown on the stone heaps out of the way. Such a supervision and maintenance of the road will be found far more economical and satisfactory than any spasmodic method of repairs can possibly be.

A difficult engineering problem has always been to find a good material for city streets. While macadamized roads are admirably suited to the country, they are objectionable in town on account of the dusty or muddy condition into which they invariably fall. Cobble stone and broken stone pavements, as usually laid, are noisy and apt to get out of repair. Those of cut stone, generally known in this country as the Russ pavements, made of cubical blocks, are, perhaps, the worst that have been yet tried; slippery, expensive, and most difficult to repair. It is true that the tractile force required upon them is small, owing to their smooth surface; but this is nearly if not quite counterbalanced by the extreme difficulty with which the draught animal moves upon it. Any horseman who has ridden over such a pavement, must have noticed that the animal moves as uncomfortably upon it as a pedestrian upon smooth ice, and great fatigue is the consequence of his endeavors to keep his footing, to say nothing of the absolute accidents which constantly happen from falls.

In the cities of Italy, (Florence, for example,) which are paved with larger blocks of smooth hard stone, no rider thinks of mounting his horse at his door, but has him led to the city gates to avoid the danger of a fall; and in such streets the carriage horses fall down and get up, as a matter of course, probably not suffering as much as we might suppose, since they know how to fall gently from long practice.

Iron, cast into various forms, has been tried, but has not come into general use, owing partly to its expense.

Probably a pavement made of small flat cobble stones, carefully picked and properly set *on edge*, in a bed of concrete or beton, would be found to be the most satisfactory pavement, until we get some arrangement of iron which will serve a better purpose.

Asphalte, a sort of mineral tar, which is found in various localities, has been used with very great success in Paris and in other European cities. It has been employed to a small extent with us, but has not met with so much favor as it deserves, probably owing to the imperfect manner in which it has been applied.

The asphalte should be melted and mixed with about one half its weight of small clean gravel, and while hot poured upon the surface prepared to receive it, immediately sprinkled with a little sand, and smoothed off with a flat wooden patten or paddle. The mistake which is frequently made in laying it is in providing a hard unyielding surface, such as a cobble-stone or brick pavement, on which it is soon worn out. A smooth surface of gravel or sand should be prepared to receive it, or if a more rigid foundation should be required, concrete carefully rammed and smoothed off may be used. When finished, an asphalte pavement presents a smooth, partly elastic, surface, almost like that of hard India rubber, or of oil cloth, over which the feet of the horses and the wheels of the carriages move almost noiselessly. It presents a continuous surface without openings and cracks, and being waterproof, is admirably adapted for roadways, or for coverings over stone bridges, for which purpose it has been extensively used.

In Paris the sidewalks are almost all made of it, and in front of the Merchants' Exchange, and several of the theatres, where the noise of passing vehicles would be objectionable, the middle of the street is covered with it. It has also been used in France with considerable success on common roads. Its cost, and a tendency to soften under the intense heat of the summer sun, are the principal objections to its general use. For the pavements of court yards and stables it is superior to any other material.

A few years ago it was supposed that plank roads, especially in wooded countries, would be found to be very cheap and satisfactory. In many localities they have been used with great success, although the opinion is gaining ground among engineers that they are inferior in every way to good gravel roads, provided that that material can be obtained at any reasonable price. They are usually made by laying two longitudinal sills of timber about six inches square four feet eight inches apart, filling up carefully with earth to their upper surfaces, and then laying three-inch plank of any width upon them. The general practice is now to lay them at right angles to the line of the road, and not to spike them. Every fifth or sixth plank has its end pushed out a few inches on alternate sides to make it easy to bring a wagon back on to the planks if it runs off.

### THIRD LECTURE.

## BRIDGES—BEAMS.

Bridges are the structures used by the engineer to carry a road over streams or dry ravines. \* They are necessarily structures, with openings beneath, of greater or less size, and portions of them at least must be adapted to carry a load over a space. The solidity of such structures depends upon the cohesion of the materials composing them, or, in other words, upon the strength of the materials, their resistance to compression or extension. When we extend a piece of any material, we draw the particles of it further apart than they are in the normal condition; and when we crush it, we force them into closer contact. These are direct strains, and can be readily made the subjects of experiment. To determine the tensile strength of wrought-iron, we have only to prepare a rod of any known section—say one square inch—and fastening it by one end in a vertical position, hang weights to the other end until it gives way. In this case all the fibres in it are equally subjected to the strain, and if we double the section, we may double the weight which it carried before. The strength is directly proportional to the section, and the calculations for any weight are of the simplest nature. The same remarks apply to the crushing weight determined by subjecting a cube of the material of known section to the action of a weight tending to crush it directly.

When, however, we come to the consideration of the strength of materials in other forms, and in positions where the direction of the force does not coincide with the axis of symmetry, we shall find that the investigations become much more complicated, and that direct experiments must be applied through some general law to special cases.

The most natural way to span an opening of moderate width is evidently to throw across it a beam of such length that its extremities will rest upon the sides of the opening. The rudest bridge is a tree felled so as to lie across a stream. Now, in a beam in this position, and of equal size throughout, we shall find that the fracture, from too great a load distributed over it, will be in the middle; and that if the section of the fracture be examined, it will give evidence of different kinds of forces having been in action at that point.

It is, perhaps, simpler in the beginning to consider half of the beam, and to determine what are the strains which are caused by the application of a load.

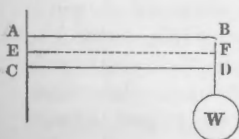


Fig. 10.

If we have a beam firmly fixed at one end in an unyielding wall, and loaded at the other end as in Fig. 10, we will find it first bend as in Fig. 11; and then, as the load is increased, break at or near the point of support A C.

Galileo, who investigated this, noticed that,



in order to change its shape, as in Fig. 11, the side A B must become longer than C D, and he supposed that all the fibres above C D were extended by the action of the weight, and that the tensile strength of the material was alone called into action.

It is evident, upon reflection, however, that if the material is at all compressible, that the fibres along C D, in the giving way, will be compressed. Mariotte first suggested this, but very vaguely. James Bernoulli afterwards examined the subject, and pointed out the fact clearly, and indicated the position of the neutral axis.

If in the Figs. 10 and 11 the upper fibres are extended, and the lower ones compressed, there will evidently be a line along which the particles will suffer neither extension or compression; and this line is called the neutral axis.

If the material is able to resist compression and extension equally well, the neutral axis will be in the middle. If it is readily extended, and resists compression, the neutral axis will be near to the compressed side, and *vice versa*. As before stated, the beam will bend before it breaks, and the amount of this bending is important, partly because in many structures great stiffness is necessary, and we should know how to attain it, and partly because it is found that any bending after a certain amount, is injurious to the beam, although the weight applied may not have been sufficient to break it at the time.

The distance that the point of the beam sinks below the horizontal line is called the deflection, and it can only be determined by experiment upon the different materials, although we may deduce the general laws which govern it.

The formula by which the law of deflection is expressed, is as follows:

$$D = c \frac{W l^3}{b d^3}$$

Where  $D$  is the deflection,  $W$  the weight,  $l$  the length of the beam,  $b$  the breadth, and  $d$  the depth,  $c$  is a constant, determined by experiment.

That the deflection should be directly as the weight, that is, that if we double the weight we will double the deflection, need hardly be demonstrated.

That the deflection is as the cube of the length is not quite so obvious. We must remember that the effect of any force or weight does not depend *simply* upon its amount, but also upon the distance of the point of application from the fixed point, upon its leverage, or, as it is properly called in mechanics, its moment. Now, when we increase the length of the beam, the weight remaining the same, we increase the moment of the weight, and therefore its deflecting power; the length, therefore, comes into the expression in that way, once.

Again, as the extension of the upper side is due to the increased distance between the particles with any particular strain, if there are more particles there will be greater extension, and so  $l$  comes again into the expression. Lastly, the angle of the deflection being the

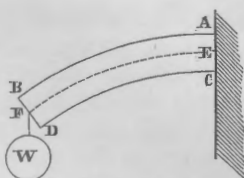


Fig. 11.

same, the actual deflection increases with the length, and so it comes in again, giving us  $l^3$ .

In the denominator of the fraction, the deflection with the same weight will be diminished as the breadth is increased, simply because there will be more material to resist, disposed in exactly the same position as before; but when we increase the depth we diminish the deflection, not only by adding material, ( $d$ ,) but by adding it at a greater distance from the neutral axis, so that it acts with a greater moment to resist the separating action of the weight. Thirdly. The amount of separation of the particles at the surface being the same, the deflection will be less as the depth is increased, owing to the angle of deflection being smaller; therefore, the deflection will be inversely, as  $d^3$ . Although we have only considered the upper surface, the same reasoning will apply to the compressed side.

The strength of the beam will also depend upon its proportions, but not exactly in the same way. It may be thus expressed :

$$\text{Strength} = c \frac{b d^2}{l W}$$

It will evidently depend directly upon the breadth or the amount of material; and if we increase the depth we not only add material, but we add it at such points, far from the neutral axis, that it will have a greater moment, and therefore give us that advantage also, whence we have  $d^2$ .

In the denominator, the strength will be inversely as the length, since increase of length will give the weight additional moment, and it will be less as the weight increases, obviously.

The angular deflection, which gave us one  $l$  and one  $d$ , and the increased number of particles, which gave us another  $l$ , in the first expression, do not come into this one at all, as a careful consideration of the subject will show.

Again, since the tendency to break at any point with a weight, increases with the distance of the weight from that point, such a beam will break at the wall, and if it is strong enough there, it is unnecessarily strong at all other points of its length, and we may economically taper it off to the end in the forms shown in Figs. 12 and 13,

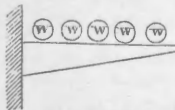


Fig. 12.

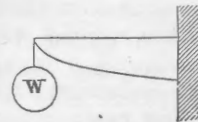


Fig. 13.

where Fig. 12 is a beam loaded with a weight uniformly distributed, and Fig. 13 one loaded at the end, the under side in this case having the form of a parabola.

In engineering structures, such beams supported only at one end do not frequently occur, and we must, therefore, consider how our expressions already deduced, must be changed to apply to beams supported at both ends and loaded in the middle. Such a beam may be considered as fastened in the middle and acted upon by two forces, acting upwards at its two ends.

In this case the lower side will be extended and the upper side compressed, as in Fig. 14.

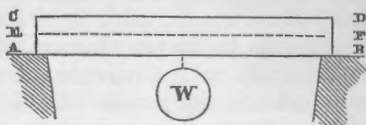


Fig. 14.

We found that while, if we added material to a beam, so as to increase its breadth, we only gained so much strength as was due to the greater number of particles; if we added to the depth we not only increased the number of particles, but also their moment, and thus gained a double advantage.

We should, therefore, in designing a beam, make it as deep and as thin as is practically possible, if we wish to economise material. The importance of this may be tested by comparing the stiffness and strength of an ordinary joist when laid on its side or on its edge across an opening.

Now, we cannot in practice reduce the breadth beyond a certain limit, since our beam would twist and fail from that cause, but, since the advantage is gained by disposing the material at a distance from the neutral axis, we may make our beam with a flange at the top and bottom, which will insure that result and give lateral stiffness at the same time.

Fig. 15 shows the cross section of a beam so made. The material in the flanges A B and C D acts with a moment due to its distance from the neutral axis G, and the material in the web, as it is called, serves merely to keep the flanges together.

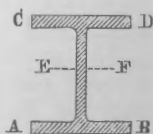


Fig. 15.

In a beam made to bear pressure equally from all sides as a straw, the material may be entirely withdrawn from the centre and disposed in a circle around the neutral axis, forming a tube or pipe, which is much stronger than it would be if the same amount of material composing it were disposed in a solid cylinder.

If the material of the beam resists extension and compression equally well, the two flanges should be of the same size, but if not, they must be unequal, to give each the share of the strain which it can bear.

Thus, a cast-iron beam with equal flanges will break always upon the lower or extended side, since the material resists compression well but extension badly; and Mr. Eaton Hodgkinson, who experimented largely on beams, succeeded, by gradually increasing the lower flange, in making one which was equally strong at the top and bottom. In this the bottom flange had six times the area of the upper one, (see Fig. 16,) and this is the form now adopted for cast-iron beams.



Fig. 16.

On the other hand, wrought iron does not resist a compressive strain as well as it does one of extension, and in a beam of this material the upper flange should have an area nearly twice that of the bottom flange.

In later examples of wrought iron beams rolled in one piece, the two flanges are made of the same size, to avoid warping in cooling, but in beams made of pieces riveted together, this proportion should be observed.



Fig. 17.

A wrought-iron beam may be modified in another way. It is sometimes advisable to divide the web into two plates, putting one on each side, as in Fig. 17, and then we have the box form, identical in principle with the usual form, but in some cases more convenient to manufacture, and possessing more lateral stiffness.

The flanges themselves may be made of several parts, and made even tubular, as we shall see in the description of the Britannia bridge in a succeeding lecture.

So far we have only considered cases in which the web is a solid plate, but it will frequently be desirable, and often necessary, to make the web of pieces, or to frame it; if we use wood this can hardly be avoided.

We must be able to arrange the parts in such a way as to insure strength and stiffness, with economy of material, for we shall thus not only save in first cost, but relieve the structure of much dead weight of material which would only load it to its injury.

In using any material in the form of rods or posts we must endeavor to direct the strain through the axis of the piece, since all material bears a direct strain of compression or extension better than any other.

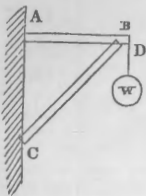


Fig. 18.

If a piece of timber projecting from a wall, as  $A B$ , in Fig. 18, is to be strengthened so as to support a weight,  $W$ , we can best do it by putting an inclined piece under it, with its lower end,  $C$ , fastened firmly in the wall. Now the triangle is the only straight sided figure, the angles of which cannot be altered without changing the length of the sides, and the point  $D$  cannot sink unless  $A$  draws out of the wall, or  $C D$  becomes shorter, since we have supposed the end,  $C$ , to be immovable.

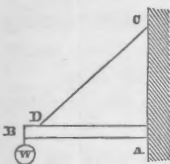


Fig. 19.

If it should not be convenient to place a brace *under* the beam, we may substitute for it a tie or tension rod *above* it, as in Fig. 19; this tie will be subjected to a tensile strain only, and may therefore be a rod of wrought iron, or even a rope or chain.

If we have, therefore, to construct a simple bridge over a stream, the width of which is too great to permit us to use a single beam, which would deflect too much, or perhaps break, we may shorten the actual span of the beam by introducing braces or struts, as in Fig. 20, where the clear span of the beam is reduced, from  $A B$  to  $C D$ , the points  $C$  and  $D$  being firmly supported

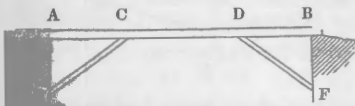


Fig. 20.

by  $C E$  and  $D F$ .

If, for any reason, it is not convenient to have such framing *under*

the bridge, we can put it above by a simple change, as in Fig. 21, where the point C is firmly fixed by the braces A C and C B, and therefore the centre point of the beam, A D, may be suspended from C by the tie rod C D, thus changing the long span, A B, into two short ones, A D and D B.

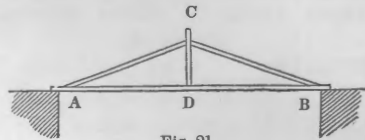


Fig. 21.

Again, if we find that A C and C B are so long as to be too flexible, we may support their center points by additional braces, D E and D F, Fig. 22; thus firmly fixing the points E and F, and should A D and D B be too weak they can be supported from the fixed points E and F by tie rods E G and F H. So we arrive by this simple process at a form which is comparatively complex.

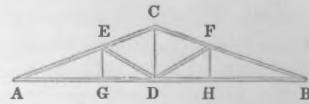


Fig. 22.

If it is desirable to make use of a material like wrought iron for stiffening, since it is peculiarly adapted to bear tensile strain, we may make use of it in a most economical manner. In Fig. 23 we have a beam, A B, trussed, as it is termed, by the iron rod, A D B, which passes under a post or strut, C D; now it will be impossible, when all the parts are tight, for the point C to sink without the lines A D and B D becoming longer. Since the strain upon the tie in this case is a direct tensile strain each fibre will be made to bear its share of the load, and it will be a very economical mode of using our material. We may modify this in such a way as to show that the strain upon such a tie is precisely the same as on the lower edge of a beam.

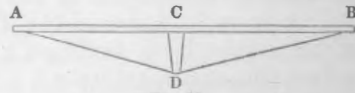


Fig. 23.

Let us suppose, in Fig. 24, that the strut is made so short as to disappear, and permit the rod to touch the beam throughout its whole length, it will still act as the tie in Fig. 23, but with diminished effect, owing to its being nearer to the neutral axis, and the moment of the resistance of its fibres being therefore less.

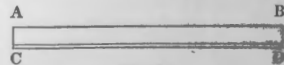


Fig. 24.

This mode of strengthening a beam is sometimes resorted to in carpentry; but that shown in Fig. 23 or Fig. 25 is preferable.

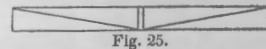


Fig. 25.

If the distance between A C to C B, in Fig. 23, is so great as to cause flexure of those parts of the beam, we may truss them again by an intermediate strut and tie, as in Fig. 26, in which the points E and F are supported in this way.

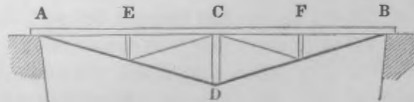


Fig. 26.

Many roofs are constructed on this plan, and up to very large spans it is the most simple and economical arrangement of wood and iron that can be made for the purpose.

Since, in a roof, the principal rafters are inclined, we shall have the

arrangement shown in Fig. 27, in which the tie A C is added, to prevent the roof from spreading and pushing out the walls.

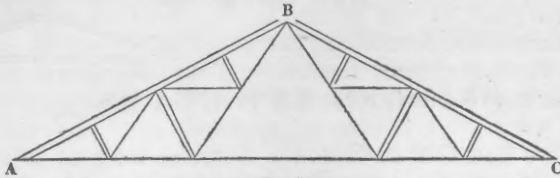


Fig. 27.

There are innumerable forms of roofs, some entirely of wood, others entirely of iron, others mixed, which take different forms, as the braces are made either to resist compression or extension, for, as we have seen in Figs. 18 and 19, we may always substitute for a tensible brace one which acts as a strut. All well designed roof trusses will, however, bear the test of an analysis, based on the principles just enunciated.

One more example may be given in which this simple form of truss is extended to adapt it to the heaviest bridges with great success.

The iron bridges on the Baltimore and Ohio railroad, and elsewhere, known as Bollman's bridges, are made, as shown in Fig. 28, where the struts *c d e f g h i*, and the tie rods belonging to them, support the beam A B at these points.

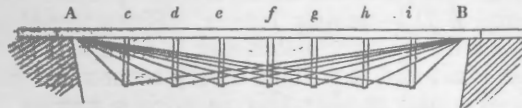


Fig. 28.

In an improvement by Fink, shown in Fig. 29, the tie rods on each side of each strut are of the same length, and therefore equally effected by changes of temperature, which is an important matter, since in Fig. 28 the struts near the ends are subjected to side strains from the unequal changes of length of the rods. This arrangement of Fink's permits, moreover, the use of much lighter tie rods for the lesser parts of the system, as indicated in the figure, and no more material is therefore used than is absolutely necessary.

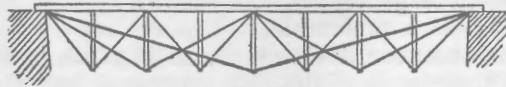


Fig. 29.

## FOURTH LECTURE.

## BRIDGES AND BEAMS.

[CONTINUED.]

The forms of triangular framing that we have noticed are not suited to all cases, and we return to the double-flanged beam, and consider its application to long spans.

There are certain limits which cannot be passed in making beams in a single piece, and recourse must be had to some arrangement of connected pieces, which will be economical and effective. If we use boiler plate we may make a composite beam of the same form as the simple ones already described, as in Fig. 30, the web being still a thin flat plate, and the flanges being formed by riveting angle irons to it. In cast iron this would be hardly practicable, owing to the difficulty of casting a thin plate of any great size. In wood it would be entirely impracticable with any regard to economy of material.

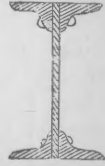


Fig. 30.

As stated before, the web may be separated into two plates, and the flanges made cellular; but we may go further, and, retaining the flanges, connect them by an open web, in which the material shall be so disposed as to resist strains under the best possible conditions.

In a beam thus made, we have a top and bottom chord or flange, connected by pieces of timber reaching from one to the other. If these pieces or posts are disposed, as in Fig. 31, they will not serve to

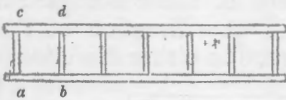


Fig. 31.

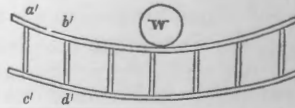


Fig. 32.

connect the chords properly, since a weight applied will cause the structure to deflect, as in Fig. 32, the posts merely transmitting a portion of the strain to the lower chord, and the whole system having no more strength than it would have possessed had the posts been omitted, and the beam made of depth equal to the sum of that of the two chords, while we desire to take advantage of the distance between the chords to give greatly increased stiffness and strength.

The shape of the spaces or bays is evidently altered by the deflection in Fig. 32 from rectangles, as in Fig. 31, to rhomboids, the two diagonals of which are not equal. Now the rectangle  $a b c d$  cannot change into the rhomboid  $a' b' c' d'$ , without  $c b$  becoming shorter, and  $a d$  longer. If, therefore, we can prevent such change of length, we can preserve the shape of the figure, and prevent the sinking of the

point *b*. To do this we may either introduce a *strut*, *c b*, or a *tie*, *a d*, as in Figs. 18 and 19. If we use a strut or wooden brace, we shall have the arrangement shown in Fig. 33.

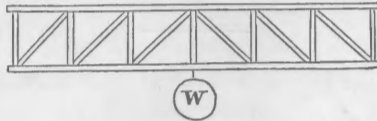


Fig. 33.

In this arrangement the beam cannot assume the shape shown in Fig. 32, without its diagonals becoming shorter; and since the braces are in the most favorable position for resisting—that is, with the strain acting in the direction of their length—a small amount of material will do a great deal of work. If it is desirable to use an iron tie instead of a wooden brace, we shall have the form shown in Fig. 34.

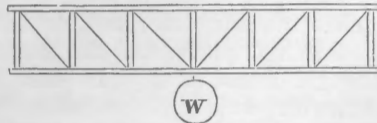


Fig. 34.

For any beam or truss, which is only intended to bear a constant and quiet weight, this bracing is sufficient, but if the load is variable and passing, as in the case of a railroad bridge, something more is needed.

In a structure of considerable length, the effect of the load at any point between the centre and the end will be to cause a rise of the corresponding point on the other side of the centre; and since the braces are not calculated to prevent such a rise, oscillations will take place which may soon destroy the structure. Such a rise at any point can only take place by a change in the shape of the rectangle; and if, therefore, we introduce another brace in the direction of the other diagonal, we shall prevent change of figure in either direction.

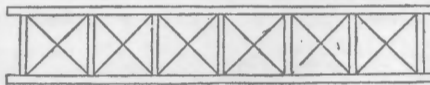


Fig. 35.

In Fig. 35 we have such an arrangement. Such braces are called counter braces, and since the strain upon them is a secondary one, and always small, they may be made much lighter than the main braces.

A little consideration will show that ties may be substituted for struts in a variety of ways, and *vice versa*. For instance, in Fig. 33, the addition of ties running in the same diagonal as the struts will counter brace the truss, and in Fig. 34, the counter braces may be light struts in the same diagonal as the ties. Again, we may do all the bracing by ties, as in Fig. 35, or we may use struts for both braces,



and put vertical ties in the place of the posts, the resistance of both sets of braces serving the purpose of the posts.

We must always bear the principle, however, carefully in mind, and not make the mistake of causing a *strut* to be exposed to a tensile strain, or a tie to a strain of compression.

It will be seen in Figs. 33 and 34 that the braces are always disposed to support a weight at the central point of the truss, and it is evident that if we cut a girder of this sort into two pieces, they will not serve as two shorter beams, since in each one half of the braces will be in the wrong diagonal of the rectangles. Although this seems simple enough, it is sometimes not understood in practice. In the lecturer's practice he has seen an iron roof which was in such a position that it could only be sloped one way; that is, it was a lean-to roof, and the builder had copied *one half* of a very good iron roof truss for his half span, the consequence being that the tie rods near the high side of the roof became struts, and being too flexible to resist a compressive strain they gave way under a weight of snow, and the roof sank in.

The story is also told of a certain double-pitched roof of an English railway station, that, during the absence of the chief engineer of the road, some wise man connected with the management proposed to strengthen it by putting a row of columns under it down the centre. His advice was adopted, and in the act of wedging the columns up to sustain the weight the roof fell in, much to the astonishment of the sagacious designer.

It is evident that by means of the braces and ties we have considerable control over the form of the beam, even after it is up, and it is usual to give a bridge a slight *camber* or curvature upwards, to insure that it shall not settle in time or under a passing load below the horizontal line. For this reason iron ties in at least one direction are convenient, since the screws and nuts by which they are fastened provide a simple means of adjustment, while the wedges that must be used in a structure entirely of wood are less easily managed.

Care must be taken in designing a beam that there is no more material used than is necessary, such excess being worse than a waste, since it increases the load which the beam has to bear.

Dr. Young called attention to the fact that, besides the tensional strain below the neutral surface and the compressive strain above it, there was a vertical strain existing near the ends, and diminishing towards the middle, which he called the shearing strain. The weight of the beam tends to shear off the fibres immediately over the point of support just as a bar of metal is cut in a shearing machine. Before this was understood, engineers were astonished to find that bridges, the parts of which had been carefully calculated, sometimes failed near the abutments while retaining their form towards the centre, and now the posts and braces are made stronger near the abutments, or additional struts, called arch braces, are inserted. In cast-iron beams with a plate web, it is proper to thicken the web near the points of support to resist this strain.

Care must be taken in deciding upon the proportions of the posts and braces that their section is not only great enough to enable them

to resist the direct crushing strain, but that it is sufficiently great, compared with their length, to avoid a sidewise flexure and consequent failure. Hodgkinson, in his elaborate experiments, has shown that, in practice, when the length of a post is less than thirty times its diameter it is not apt to break without it is absolutely crushed; but in such cases the ends should be square and well fitted, and the strain should be central, and not on one side. Posts with rounded ends are much weaker than those with flat ones.

When a post, subjected to an axial crushing strain, is inclined, as in the case of a main brace in a bridge truss, we must bear in mind that its deflection from its own weight will tend to weaken it as a strut, since it commences the flexure to the side which is the ultimate cause of the failure of a strut. For this reason, if the cross section of such a strut is not a square, and if the length is at all great, the greatest side of the cross section should be vertical, as in the case of a beam or joist. If a timber strut seems to be too flexible it may be much stiffened without adding much to its weight by spiking to the upper or lower side a *fin* of narrow plank, deep in the middle and tapering off towards the ends.



Fig. 36.

Cast-iron struts should either be tubular or have a cruciform section, as in Fig. 36, so that the material being disposed at the greatest distance from the neutral axis may act with the greatest effect in preventing what we may call the initial flexure. Wrought iron may be used in both these forms with great economy of material, a piece of ordinary gas pipe forming the best of struts, and the cruciform section being readily got in the rolls of the mill. In fact these remarks apply to all pieces subjected to a compressive strain, such as posts, struts, and the upper chords of framed beams or bridges, the tubular or the cruciform section being necessary where economy of material and lightness of the structure are desired.

Since, in practice, it is not always convenient or possible to span a chasm by one single beam, intermediate supports (piers) must be made use of, and, in an iron structure at least, advantage may be taken of them to assist in relieving the strain at other points of the beam beside those immediately over them. If the spaces are spanned by unconnected beams, as in Fig. 37, each one will act independently, as



Fig. 37.

there shown, but if the whole is continuous, as in Fig. 38, it will behave differently.

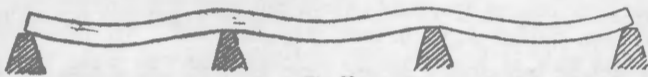


Fig. 38.

If, by any means, in Fig. 37, we were to raise the middle points of the deflecting beams into a straight line the triangular spaces between

their ends would close up, and the upper edges would touch. Now if, when in this condition, we unite in any firm way these upper edges, when we take away the support from below, the beams cannot sink to their original position, since the triangular spaces cannot open, and the tensional strain thus brought upon the upper edge over the pier will tend to neutralize the compressive strain always existing on the upper edge of a beam. In a wrought-iron structure this may be very easily done by raising the ends A and C until the gap at B is closed, and then riveting the upper plates together. Upon letting the ends A and C down again the deflection between them is diminished. This was most successfully done in the case of the great Britannia Bridge.

Professor Gillespie has determined that with a flexible beam on three supports, each support bears the portion of a uniformly distributed load indicated by the fractions, in Fig. 39, and on four supports as in Fig. 40.

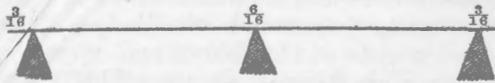


Fig. 39.

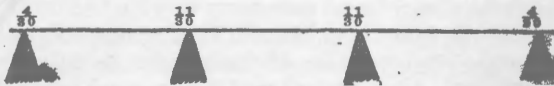


Fig. 40.

It is evident that a flexible beam with a uniformly distributed load may be so placed on four supports that two of them will not bear any part of the weight, as in Fig. 41.



Fig. 41.

A few words upon the practical considerations involved in the use of iron in engineering structures, will not, perhaps, be amiss. In this country where timber is abundant, and labor and carriage dear, wood has been used to a great extent for bridges, and when iron has been resorted to, wrought has usually been preferred. In England, however, where the engineering taste is decidedly for the ponderous, cast iron has been used to a considerable extent, and ample opportunity has been afforded for a comparison of its merits with those of wrought iron.

Cast iron is crystalline, hard, brittle, and non-elastic; it bears a crushing strain up to from 80,000 to 100,000 pounds per square inch, and a tensile strain of about 15,000 pounds.\*

Its principle advantage is the ease with which it can be cast into any required form, and for heavy masses, or for pieces of nearly equal

\* Eaton Hodgkinson.

dimensions each way, or for posts subjected only to a statical strain, it is admirably adapted. For beams, or portions of beams, especially where it will be subjected to varying strains, to vibrations, and to the action of intense cold, it should be used with extreme caution.

When a single casting has some portions much thicker than others, most dangerous strains are induced by unequal cooling and contraction; parts being in this way subjected to tensions, which a small added load will render sufficient to cause total destruction of the casting. Square corners and square openings in a casting are peculiarly dangerous in this respect, and should be most carefully avoided. Again, in a casting which is somewhat irregular, bubbles of air are apt to be entangled, and they cause holes or flaws, which frequently cannot be detected on the outside, even by the aid of the hammer. The iron being deficient at these points in the cross section, weakness is the result.

Under a sharp sudden blow cast iron breaks instead of bending, and great cold seems to render it brittle.

Wrought iron, either hammered or rolled, is tough, elastic, and homogeneous, and resists sudden blows and vibrations much better than cast. It bears a crushing strain up to 60,000 pounds per square inch, and a tensile strain of about the same.

In practice it has been found necessary to give the upper flange about twice the area of the lower one, since a thin wrought-iron flange, being soft, yields by buckling, although its resistance to compression per square inch of section, is nearly equal to, or, perhaps, a little greater than its resistance to extension. As I have elsewhere stated, beams are now rolled in this country in one piece, with the two flanges of equal areas, and with care in proportioning them, this is an economical form.

Since wrought iron is brought to its form by hammering or rolling, there can be no flaws in it from air bubbles or similar causes, except in the very rare case of some foreign matter being inclosed by accident in the mass. For the same strength as a beam it has less than half the weight of cast iron, an important consideration in very large structures, of the foundations of which the slightest suspicions are entertained.

Its superior elasticity enables it to resist sudden shocks, or the strains caused by the unequal settling of adjacent parts, and its toughness, enables us to make fastenings to resist a tensional strain with great facility.

Fairbairn has shown that, at English prices, a wrought-iron beam, to sustain a given weight, can be made for nearly the same price as one of cast iron, with the advantage of much less weight. His statement is as follows:

Cast-iron beam, 31 feet 6 inches long, 22 inches deep, weighs 4,480 pounds.....	\$65 00
Wrought-iron beams, 31 feet 6 inches long, 22 inches deep, weighs 1,834 pounds.....	\$65 50

To bear a weight of 25.5 tons in middle, or 55 tons distributed uni-

formly over it. If a great number of such beams were to be raised to a considerable height, the small difference would probably be in favor of the wrought iron.

In cases therefore where a portion of the structure is much elevated, where it is desirable to reduce the load on the foundations, and especially where wrought iron, in its simpler forms, as in tubes, bars, rods, and plates, can be used, this material is entitled to a decided preference over cast metal, and it will undoubtedly come gradually in general use.

The most interesting case of a large wrought-iron beam, in a scientific point of view, which we have on record, is that of the Britannia Tubular Bridge, built over the Menai straits, for the Chester and Holyhead railway, in 1849, by Robert Stephenson, C. E.

Certain restrictions imposed by the Admiralty upon the construction of a bridge over this strait, induced Mr. Stephenson to decide upon some form of beam which could be built on the shore, and then raised into its place at an elevation of over one hundred feet—an operation which will be referred to in a succeeding lecture. The span of the longest beam was to be 460 feet.

At that time Mr. Stephenson, in common with the rest of the profession in England, considered the suspension bridge as a structure entirely unsuited for railway purposes, and he was therefore required to devise a bridge necessarily different from any existing examples. After having abandoned the idea of a cast-iron arched bridge of peculiar construction, he supposed that a wrought-iron hollow beam or tube might be made, supported by chains at the central point, and he called to his aid Mr. William Fairbairn, an engineer already much distinguished for his various experiments on materials of construction.

Mr. Fairbairn undertook at once an extended series of experimental investigations, beginning with the circular and elliptical tubes suggested by Mr. Stephenson.

Although direct experiment on small pieces had shown, as already stated, that the resistance of wrought iron to compression was about the same as to extension, these experiments soon showed that the upper surface of the beams failed first, from a buckling or crimping of the iron, owing to its flexibility, and pointed out the necessity for an increase of material in the top.

In short, a large number of experiments induced Mr. Fairbairn to recommend the form of beam afterwards adopted; a section of which is shown in Fig. 42, where the material in the upper side bears to that in the lower the proportion of 565 to 500, and is so disposed to resist the crushing strain to the best advantage. The cells or divisions shown in the figure are made by introducing vertical iron plates, and riveting to the horizontal plates through angle irons in the corners, thus forming an upper flange; which, as shown by the experiments, would bear, without buckling, a strain approaching to the experimental crushing strain of wrought iron.

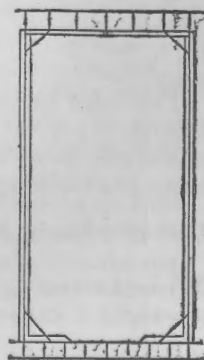


Fig. 42.

The bottom of the bridge, since it resists only a

direct tensile strain, or acts as a chain, need not be cellular; and, in a later example, by the same engineer—the Victoria bridge over the St. Lawrence river—the bottom is composed of plates riveted closely upon each other without cells, and the cells of the top are replaced by vertical fins, which serve the same purpose.

In the Britannia beam the sides are quite thin, serving only to connect the upper and lower flanges, and they are stiffened by fins of T iron riveted vertically over the joints. Near the ends of the beam the sides are additionally strengthened to provide against the shearing strain.

To avoid change of figure laterally by the action of the wind, triangular plates are fixed at the top and bottom, as shown in the figure. Further details in regard to this beam, and the description of the manner of raising it, will be given in the next lecture.

[The remainder of the lectures of this course will be given in the appendix to the next annual report.]

# LECTURES

ON

## MOLLUSCA; OR "SHELL-FISH" AND THEIR ALLIES.

PREPARED FOR THE SMITHSONIAN INSTITUTION,

BY PHILIP P. CARPENTER, B. A., Ph. D.,

OF WARRINGTON, ENGLAND.

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Who has not admired the beauty of shells?—the rich luster of the Cowries; the glossy polish of the Olives; the brilliant painting of the Cones; the varied layers of the Cameos; the exquisite nacre of Mother-of-pearl? Who has not listened to the mysterious "sound of the sea" in the Whelks and Helmets, or wondered at the many chambers of the Nautilus? What child ever went to the sea shore without picking up shells; or what lady ever spurned them as ornaments of her parlor? Shells are at once the attraction of the untutored savage, the delight of the refined artist, the wonder of the philosophic zoologist, and the most valued treasures of the geologist. They adorn the sands of sea-girt isles and continents now; and they form the earliest "footprints of the sands of time" in the history of our globe. The astronomer, wandering through boundless space with the grandest researches of his intellect, and the most subtle workings of his analysis, may imagine, indeed, the history of past time and speculate on the formation of globes; but his science presents us with no records of the past. But the geologist, after watching the ebb of the ocean tide, examines into the soil on the surface of the earth and finds in it a book of chronicles, the letters of which are not unknown hieroglyphics, but familiar shells. He writes the history of each species, antedating by millions of years the first appearance of man upon this planet, the abrasion of the Mississippi Valley, or the roar of the Niagara at Queenston Heights. He searches deeper and deeper into the rocky crust of the globe, still finding the same types in older characters. As he climbs the rocks of Trenton or Montmorenci, he treads on the tide-ripples, the rain drops, the trails of living creatures in the ancient Silurian sea, which he interprets by the Rosetta Stone of Chelsea Beach or Charleston Harbor; and as he reverently unlocks the dark recesses which contain the traditions of the early ages, between the dead igneous rocks and the oceanic deposits which entomb the remains of life, the first objects which meet his gaze are the remains of a thin, horny shell, so like those now living in the Atlantic and Pacific waters, that the "footprint" enables him to reconstruct a Brachiopod with delicate ciliated arms and com-

plex organization, such as is figured in the beautiful works of Owen and Davidson, from dissections of the existing species.

For be it observed that shells are not things without life, as they are often taken to be by thoughtless admirers. Nor are they simply the *habitations* of "shell fish," as ordinary observers consider them. It is common to regard the snail-shell as the *house* which the creature has made and carries on its back, having a relation to the animal inhabitant analogous to that of the cocoon to the chrysalis or the nest to the bird. Even viewed in this light, shells would be most interesting objects of study; representing the different styles of architecture invented by these insignificant mechanics. Such appears to have been the way in which the great Linnæus regarded them; for he described the animals under other names than those of the shells. Indeed, he appears to have considered the houses of far more importance than their inhabitants; for, while he divided the shells into genera and species, he was content to group all the living inhabitants under five names, saying in the description of each genus "Animal a Clio," &c.\* Even in his error, however, the great Father of Natural History showed his close discernment; for these five divisions correspond almost exactly to the classes afterwards prepared by Cuvier, and now generally adopted.

Let it be distinctly understood, therefore, at the outset, that shells are truly organic structures, part and parcel of the living animal, as truly as the nails of man, the plumage of birds, the armor of armadillos and crocodiles, the scales and cartilage of fishes, or the shell of the sea urchin. They are more truly part of the living inhabitant than the skin of caterpillars or the shell of crabs, inasmuch as they are not periodically cast off, but remain, as the hardened skin of the creature, during its whole period of existence. To collect and arrange shells, therefore, bears the same relation to science as to collect and arrange stuffed birds and beasts; in either case we know only a part of the peculiarities of the animal. The mere museum-student would not know the porpoise to be a mammal; nor discriminate the manatee as being an abnormal pachyderm; nor observe the wide separation between the horse and the hoofed ruminants. So the mere conchologist would associate the Wendletrap with the top-shells, the nerites with the *Naticas*, the *Cerithiums* with the whelks, &c., not knowing that the animals are structurally as much unlike as the mammals just mentioned. It is absurd, therefore, to study shells without examination of the soft parts of the animals; while, to study the soft parts alone, without regard to the differences in the shells, would be like endeavoring to classify the cat-tribe from examination of tigers, panthers, &c., which had been previously skinned.

No one despises a collection of stuffed birds because so few of the creatures have been dissected; so we ought not to despise the study of shells because we know so little of their inhabitants. But the bird skin tells us much more about the bird than does the shell about the "shell-fish;" because the shell is the hardened skin only of a portion

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\*The Linnæan Molluscs are *Sepia*, *Limax*, *Clio*, *Anomia*, and *Ascidia*. The animal of *Terebratula* was not then known.



of the animal, (called the mantle,) the head and foot, and other important members, not leaving any impress on their unpliant covering.

It is only of late years that enquirers have even attempted to gain information about the animals of shells. The very beauty of the shell has contributed to this result. Every sailor could collect shells, and every lady could lay them on cotton in a drawer; the animal was a nuisance, liable to rot if not carefully extracted, only to be preserved in bottles of spirit, and then presenting nothing but a shriveled or shapeless mass, fit only for the dissector's knife. Even the figures of living animals in the works of scientific voyagers are by no means infallible, it being not uncommon to find voracious proboscids figured with a vegetarian snout, or to see the shell turned the wrong way on the back of the crawler. When it is remembered that a large proportion of "shell-fish" live in deep water; that even those which surround our coasts can be but seldom examined in their natural condition; that very few will breed in confinement, and that travelers are very seldom able to dissect and examine microscopically, or even to draw correctly while on their expeditions; we must be content to wait many years before this branch of natural history is as satisfactorily established as other branches of popular science.

Let not this, however, deter any one from its pursuit. If we only collect, arrange, and study *shells*, we are doing something. We at least prepare a store of materials for future use. And every one can examine alive and report upon the shells of his own locality, whether land, fresh water, or marine. There is not a schoolboy, or a western farmer, but what may be not merely a learner of what others have done, but a gainer and teacher of fresh knowledge: while to those who can engage in scientific travel, there is open a field of original research, such as but few branches of science have left untrodden. At the present moment, we cannot agree upon the main divisions of our classification of shell-fish, for want of knowledge of the animals, habits and food of some of the commonest shells, which are annually collected by the hundred or the thousand merely for the purposes of trade.

In old days, when every one followed Linnæus, it was easy to count whether a shell had one, two, or many valves, and name it, with confidence that its place would not have to be disturbed. In the second epoch of study, after Cuvier had introduced an approximation to a natural system, all the world laid aside the artificial method, and arranged their books and shells according to the system of Lamarck. But now that we are as much in advance of Lamarck as he was of Linnæus; and every fresh animal that is examined may alter our classification; we must be content to alter and amend our books with every succeeding edition, and not allow ourselves to consider anything as fixed. The arrangement proposed in these pages may serve as an approximation to the truth, or as a starting point to begin from; neither ignoring recent discoveries, nor departing from recognized facts without better authority than hasty observations.

Another difficulty is much more serious. Most of the early naturalists, and many in our own day, have been in the habit of naming shells without describing them; or have described them so loosely that it is a matter of opinion only what they meant by their words; or have

taken no steps to make their works known in other countries. In real, and even necessary, ignorance of their labors, or in despair of understanding them, or purposely ignoring the existence of what was carelessly done, the same shells have been named over and over again, thereby burdening the memory and confusing the young student with a mass of unnecessary, meaningless, or even barbarous terms. Even this evil could be borne; for the synonymy could be made out, and henceforth all but the right name disregarded; if naturalists were agreed as to the right principles of selection. The absolute law of priority is followed by some as the most convenient. Others think that to discard names universally accepted, merely because some obscure amateur published a tract a few years earlier, or some Curator of a museum wrote his fancy names on the specimens a year in advance, or an auctioneer named his wares to effect a sale, is to strain a principle contrary to the law of use. The British Association for the advancement of Science issued a series of regulations which were generally approved, and which were republished by the American Association. But Science is a republic in which the minority refuses to be ruled by the majority; and it so happens that the newest authors have set the Scientific Associations at defiance. Those who have no access to books naturally follow the newest authorities, especially when these have deserved well of science by their discoveries. Hence we must hold our names in abeyance, and wait till better times; taking care at any rate not to add to the confusion. The limitations of the law of priority laid down by the British and American Associations appear however to be sound. A naturalist ought not to want his own name to appear, even though the first given, if the wide use of another makes it more convenient for science. Personal considerations ought always to give way to utility: because the knowledge is the end; the helpers to the acquisition of that knowledge are only means to that end. And what of honor the Christian naturalist would not claim for himself, against the uses of science, he is not bound, for the mere semblance of justice, to reserve for others. According to the laws of all civilized nations, possession of property for a given term of years confers legal right. A similar statute of limitations for scientific nomenclature would save a vast amount of time from being frittered away on merely archæological research, or worse than empty recrimination.

Those who are not deterred by the above statement of difficulties from the study of shells are recommended to possess themselves of the following works: "Woodward's Manual of the Mollusca: London, John Weale."—"Philippi's Handbuch der Conchyliologie und Malacozoologie. Halle, 1853."—"Genera of Recent Mollusca by H. & A. Adams: London, Van Voorst."—Dr. J. E. Gray's "Guide to the Systematic Distribution of Mollusca in the British Museum, London."—Chénu's "Manuel de Conchyliologie et de Paléontologie Conchyliologique: Paris." These are all cheap books. Woodward's contains by far the greatest amount of information in the smallest compass, and is well illustrated. The work of Philippi has no plates, nor has that of Gray. The Adams' figure the animals when known; but, with Gray, disregard the British Association rules, and upset the familiar Lamarckian names. Chénu's work (which, with Gray's, is still un-

finished) is for the most part a reproduction of Adams' Genera with the addition of fossils; and is chiefly valuable for its copious and accurate figures of shells illustrating the subgenera. The following pages are intended simply as an introduction to any of the above works. Books of older date are necessarily so full of errors that they should not be studied till after the student has become familiar with the present means of knowledge.

Shell-making animals have been so little known, that we have no English word to express them. They are commonly called "shell-fish," because most of them live in the sea. "Fish" are, properly speaking, cold-blooded vertebrates breathing by gills. It is a strange assemblage which groups with these the warm-blooded whales; the oysters and whelks; the jointed craw-fish; and the radiated star-fish. Just as we have been obliged to import the Latin word *mammal*, to include men, whales, bats and tigers, which are all warm-blooded, and suckle their young; so we must import the word *mollusk*, to include snails and slugs, oysters and clams, cuttles and tunicaries; all of which agree in having *soft bodies without jointed limbs*; the nervous system being irregularly distributed in knots, or *ganglia*, the principal of which surrounds the throat like a collar.

In general shape, they are very dissimilar from each other. Some have a large head with staring eyes; others are blind and headless. Some have many feet, others one, while whole classes have no organ of locomotion whatever. Some are so highly organized that many true fishes have to confess their inferiority: while some have special organs so little developed that it is doubtful whether they should be called degraded mollusks or superior zoophytes.

It is by no means a necessary condition of a mollusk to be shell-bearing. The lowest tribes have none; in the highest they are only occasional or rudimentary, or are altogether absent; the land and sea slugs are destitute of hard parts; and some even of the bivalves are almost entirely horny. The name "shell-fish" therefore, as applied to the whole group, will have to be given up; because myriads of species live on land and breathe air, and even the water species are not true fish; and because a large proportion of them have no shells.

Mollusks form one of the five great primary divisions of the Animal Kingdom. They rank side by side with the *Articulata*, or *Jointed Animals*, which include Spiders, Insects, Crabs, Worms, &c. The Sea-Worms, which have calcareous shells; and the Barnacles which formed part of the "multivalve shells" of Linnæus, but which are now known to be degraded crabs, used to be considered mollusks, and are still seen in collections of shells.\* Strange as it may seem, these apathetic creatures have much closer relationship with spiders and butterflies. The mollusks are specially designed for eating; the artic-

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\* The Cirripedes were thought by early naturalists to be the fry of Barnacle Geese. Very learned descriptions are on record, illustrated by figures accurately representing the author's imaginations, showing how the barnacles grew upon trees in the water, and at last came forth from their shelly eggs as full-fledged birds. The reality is scarcely less surprising than the story: for it is now known that these creatures begin life as an active little crab, with legs, head and eyes all complete, swimming about in the open sea. Instead of developing how-

ulates for locomotion. The highest mollusks are superior animals to the highest articulates; in both cases the lowest are inferior to many radiates. It is usual to rank them in parallel groups, thus:—

VERTEBRATA.

MOLLUSCA.

ARTICULATA.

RADIATA.

PROTOZOA.

The VERTEBRATES include *Mammals, Birds, Reptiles, Amphibians, and Fishes.*

The RADIATES include *Sea-Urchins, Jelly-fish, Coral-insects, &c.*

The PROTOZOA include the simplest forms of animal life, such as sponges, animalcules, and Rhizopods or Foraminifera. These last were till lately ranked with the highest mollusks, because they make chambered shells.

The principal classes of articulates have already been pointed out: those of the mollusks are as follows.

- I. CEPHALOPODS, or *Head-footed Animals.*
- II. GASTEROPODS, or *Crawlers.*
- III. PTEROPODS, or *Wing-footed Animals.*
- IV. LAMELLIBRANCHS, or *Bivalves.*
- V. PALLIOBRANCHS, or *Lamp Shells.*
- VI. TUNICATES, or *Cloaked Animals.*
- VII. POLYZOA, or *Molluscan Zoophytes.*

We propose to give a general description of each of these classes, which are as different from each other as are beasts, birds, and fishes; and to furnish some account of the families and more important genera. The typical mollusks are the Gasteropods, of which Snails, Limpets, Whelks, and Cowries are familiar examples. In the same way the typical Articulates are not the highly organized Spiders, but the widely diffused Insects. We shall begin, however, with the less known and aberrant Cephalopods, which hold undisputed rank at the head of all invertebrate animals.

## CLASS CEPHALOPODA.

(*Cuttle-fish and their Allies.*)

Imagine a creature with two staring eyes, which he carries under his arms, and which are more complex in structure than those of many

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ever into something more perfect as do the caterpillars, tadpoles, &c., they lose not only their feet but their eyes and their very heads; adhere to rocks and sea-weed or floating timber; become almost shapeless lumps enclosed in an acorn or barnacle shell, only betraying their articulated origin by the delicate groups of feathery jointed cirri, by waving which they induce the tiny ocean currents which bring them their food. There was nothing but the resemblance of these cirri to the feathers of birds to form a groundwork for the goose story.

fishes. His nose is a long snout, or rather a pipe, which he wears under and between his eyes, as it were on his breast. He carries his mouth at the very top of his head, and could soon make one feel the bite of his powerful horny jaws, which are hooked, and work up and down like an eagle's. Although he has no legs, he is better off for arms than a monkey, having always eight or ten, sometimes a much larger number. These he elegantly arranges in a circle round his mouth; forming a crown—more dangerous than the fabled hair of serpents—round his head. His body appears only of secondary importance, and is inclosed in an oval or conical mantle, ending often in a tail like a fish, or adorned with fins, one on each side. Imagine this creature walking on his head, with his tail upwards, staring at you with both his eyes. As you watch him, he rapidly changes color, like a chameleon, by means of thousands of contractile pigment-cells all over his skin. He may change from yellow to red or brown, sometimes casting over himself a bluish tinge; the colored spots and waves appearing and disappearing with the greatest velocity. Though not a literary character, he always carries an ink-bottle, and generally a pen, along with him; and, should you chance to disturb him, he will instantly discharge a copious black stream before you, under cover of which he will dart off before you have time to follow his retreat.

The Cuttles have very acute senses. They have an approach to a brain, inclosed in a cartilaginous skull. They can hear sounds, and evidently enjoy the taste of their food. They have a large, fleshy tongue, armed with recurved prickles, like that of the lion. They either crawl on their head, tail upwards, or swim, tail foremost, by striking their arms; or squirt themselves backwards by forcing water forward, through their breathing funnels.

They are ferocious creatures, the tyrants of the lower orders, and do not scruple to attack and devour even fishes. The larger kinds are deservedly dreaded by man. Their weapons consist in their powerful arms, which are abundantly furnished with rows of cup-like suckers, each of which fastens on to its prey or its foe like a limpet to the rock. Often these are accompanied with sharp curved teeth, strong enough to be preserved even in the fossil species. "It must be a fearful thing," says Dr. Johnston, "for any living creature to come within their compass, or within their leap, for, captured by a sudden spring of several feet, made with the rapidity of lightning, entangled in the slimy, serpentine grasp of eight or ten arms, and held by the pressure of some hundreds of exhausted cups, escape is hopeless." With such strength do they clutch the object of their desire that it is often easier to tear off the limb than induce them to relax their hold.

They are the largest of all animals that are not supported by a jointed skeleton. One was seen in the equatorial Atlantic, which must have weighed two hundred weight. Another was seen in the Pacific, which must have been six feet long. As it is almost impossible to capture these great creatures alive, we remain in great ignorance about them. Montfort, one of the early conchologists, represented a "kraken octopod" in the act of scuttling a three-master; but he told his friend that, if this were "swallowed," he would in his next

edition represent him as embracing the Straits of Gibraltar, or capsizing a whole squadron of ships.

The *shell*, in the typical Cuttle-fish, is not the hardened outside skin, as in ordinary mollusks; but, if present at all, is (with one exception) an internal appendage, answering the purpose of a skeleton, but having nothing to do with protecting the nervous centres.

All the true cuttles and their allies have eight or ten arms, provided with suckers; two gills, with superadded branchial hearts; and a body shaped for an active, predatory existence. They form the

## ORDER I. DIBRANCHIATA,

or *two-gilled Cuttles* of Prof. Owen. The first group are content with eight arms only; the rest have, in addition, two long arms or "tentacles," which serve to seize the prey at a greater distance.

### GROUP I. OCTOPODA. (*Eight-footed Cuttles*.)

Most aberrant among these aberrant animals are the

#### *Family ARGONAUTIDÆ,*

or "Paper-Sailors," so called from the delicate, white, boat-shaped shell, in which they were fabled to sail on the surface of the waters. The Argonaut was known to the ancients, one species being common in the Mediterranean. It was the *First Nautilus* of Aristotle, who, though generally so accurate, here invented or perpetuated a very pleasing fable. He described the Argonaut as sitting in its elegantly-keeled white and almost paper-like boat, holding up its two broader arms to catch the breeze, and using its other six as oars. In this position it is figured in all the older works on natural history: for either the authority of Aristotle, or the beauty of the story, caused it to be repeated from author to author, like the fable of the "Barnacle Geese." Even the naturalists of the present generation have gravely doubted whether the cuttle always found in the Paper Nautilus were the real former of the shell. A very similar shell, the Carinaria, or glassy nautilus, was known to be formed on a very different animal, a true Gasteropod. It was supposed that the greedy Octopod, having devoured the Argonaut, possessed himself of the shell, after the fashion of the hermit crabs, which may be seen crawling, tail foremost, into shell after shell, till they find one to fit them. It was reserved for a lady to set these doubts at rest. Madame Power, finding the Argonauts common in the Mediterranean, inclosed a space with net work to allow free ingress to the water, and there established her colony. She found that the Octopod was the true inhabitant of the shell, although not fastened to it by muscular attachment. She performed many experiments on her captives, the results of which have been either confirmed or corrected by succeeding naturalists. The Argonaut generally crawls on the ground with her six sucker-covered feet, carrying her shell on her back, like a snail, enveloped in the two sails, or broader arms. When she chooses to swim, she does not float above the surface of the sea; but darts through the water backwards, in the

direction of the nucleus of the shell, her sail arms still enveloping the frail bark. She generally folds her "oars" together, at arm's length, though she uses them occasionally to direct or assist her movements. What then is her propelling power? She simply *breathes herself on*, or rather *blows herself backwards*, forcing out the water from her long gill-funnel, and so is carried forward in a contrary direction. She never turns her back on her enemy; but, on the other hand, she cannot help *looking back*, wherever she is going. We say "*she*;" for strange to say, all the paper-sailors turn out to be females. For a long time the lords of the Argonaut creation eluded the anxious search of their brethren of the human species. At last they were found in the form of little stunted octopods, without any shell or sail-arms, not more than an inch long. Let tyrannical husbands see what becomes of their sex in the very highest of the invertebrate animals. The male Argonaut is not known to hold any communication with his (to him) giant mate, who lives by herself in her palatial shell. The little fellow sends one of his arms, by itself, on the courting errand; and the lady receives her spouse in the form of what was at first regarded as a parasitic leech. M. Koelliker found that what Cuvier had described as the *Hectocotylus octopodis*, was simply the contents of the left arm of the third pair on the male Argonaut, which is developed abnormally as a colored bag, and periodically gives birth to a Hectocotyle. This having been filled with spermatozoa from the body of the little Argonaut, goes forth on its independent existence, looking like an arm of an octopod ending in a thread. It lays hold on the female Argonaut with its suckers, as though it had a life of its own. It is found on her arms, clinging to her nose, or even inside the gill cavity. It clasps with such strength that it is difficult to detach it; and yet it has no mouth or other organs for maintaining life. After it has communicated the fecundating influences to the ova, it perishes. It follows that the beautiful paper nautilus is not a true shell, but simply a female appendage to deposit and mature the eggs, and at the same time protect the parent. The newly hatched Argonaut has no shell; and is said to be shaped like a worm with suckers. This beautiful group belongs only to the existing conditions of our globe. One species alone is found fossil, in the Subappennine tertiaries of Piedmont. It is now living, but not in the Mediterranean, where it is displaced by another species: it has itself migrated to the present China seas.

#### *Family* OCTOPODIDÆ.

The naked octopods resemble the male Argonaut; and some (but not all) of them have the same singular degradation of the lordly sex. They generally have small, round bodies without fins, the head and arms being the principal part of the creature. They are seldom gregarious, but crawl in the neighborhood of the shore, the small species inhabiting pools between tide marks. Here they escape detection by coloring themselves to suit the bottom, and moor themselves to crevices in the rocks awaiting their prey. They are more or less webbed between the arms, like an inverted umbrella; and progress by flap-

ping the whole at once. They can crawl at the rate of seven feet a minute; and when wishing to go quicker, they blow themselves out like a bladder, and roll over and over with great speed. They were called *polypes* by the Greeks; and some species bear a strong general resemblance to what are now called polypes, the jelly-fish, and their allies. The cuttles may be said to *represent* the radiates among the mollusks, but in their organization they are as different as birds and butterflies. The genera are *Octopus*, *Cistopus*, *Pinnoctopus*, *Eledone*, and *Cirroteuthis*. They differ in the arrangement of the suckers, and in the presence or absence of aquiferous pores in the skin and fins on the body. The *Eledone moschata* emits a strong smell of musk. The *Cirroteuthis mulleri* has its slender arms ciliated, with a web extending to their extremity. It inhabits the shores of Greenland. The

#### *Family* PHILONEXIDÆ

differ from the typical octopods in being gregarious, living in the open sea. They hide themselves by day; but towards evening come up in great shoals, to prey upon swimming mollusks and zoophytes. The genera are *Philonexis* and *Tremoctopus*.

#### GROUP II. DECAPODA. (*Ten-footed Cuttles.*)

These differ from the Octopods in having an additional pair of arms, much longer than the others, called tentacles. They are generally club-shaped at the end, and armed with a horny ring round the suckers, or sometimes with claws. They are within the circle of the eight arms, between the third and fourth pairs; and are (for the most part) capable of being drawn in to pouches behind the eyes. The body is long, always finned, and strengthened by an internal appendage; which is a horny pen in the squids, a "bone" in the true cuttles; a spiral, chambered shell in *Spirula*; a complex organ with a chambered shell inside in the *Belemnite* tribe. The eyes are movable in their orbits; the breathing funnel is generally provided with a valve; and the mantle is supported by internal fleshy bands.

#### *Family* CRANCHIADÆ.

The *Cranchia* is a pot-bellied little creature, with very small head and eyes. These are covered by the skin; the mantle is supported by two internal fleshy bands; and the breathing-pipe has a valve.

#### *Family* LOLIGOSIDÆ. (*Calamaries.*)

In *Loligopsis*, which is a very long animal with a small head, the eyes are large and beautiful, and the breathing-pipe is without valve.

#### *Family* CHIROTEUTHIDÆ. (*Hand-Calamaries.*)

The body of the Hand-calamary, (*Chiroteuthis*), seems only like a fulcrum, from which to move its powerful head organs. Though only two inches long, the arms are eight inches, and the tentacles extend



three feet. It must be remembered that these are not mere feelers, like the antennæ of insects, but strong muscular threads beaded with suckers, and armed with four rows of pedunculated claws on the expanded ends. How easily these will encircle any unhappy creature floating at a distance, and carry it to the mouth, to be torn up by the horny bills, is at once evident. How so small a body can work the muscles at such a tremendous leverage, without any support but a loose horny pen, is indeed a marvel.

The *Veiled-calamaries*, (*Histioteuthis*,) have six of their arms webbed together, leaving the other arms and tentacles loose. It resembles half an expanded umbrella. One of the species "rivals in color the brilliancy of the butterflies of tropical suns. The large membrane which unites its arms is of a rich purple, and the suckers are sapphire, the under surface being studded with blue and yellow spots on a reddish ground, sprinkled with purple spots."

*Family* ONYCHOTEUTHIDÆ. (*Sea-Arrows*.)

These creatures have the mantle supported by three internal cartilages. The eyes are exposed, and furnished with a slit above. The breathing-pipe has a valve, as in *Cranchia*. They are very numerous, and have been divided into the following genera: *Enoploteuthis* (Armed-calamary), *Ancistrocheirus*, *Abralia*, *Verania*, *Acanthoteuthis*, (Spiny-calamary); *Onychoteuthis* (Hooked-calamary); *Ancistroteuthis*, *Onychia*; *Ommastrephes* (Sea-Arrows, or Flying-squids); and *Thysanoteuthis* (Fringed-calamary).

Among the active cephalopods, perhaps the most vigorous swimmers are the *Armed calamaries*. They are the dread of the shell divers of the Pacific Islands; for the arms have, beside the suckers, double rows of horny hooks concealed by retractile webs. A cat's paw is quite sufficiently disagreeable, with her five claws; but for a bather to feel his naked body embraced with eight snake-like arms, with cat's-paw weapons on the whole length, and leech-like suckers in addition, to say nothing of the long tentacles still more powerfully armed,\* and directed by two great staring eyes, much more serviceable than a man's in the water, the possessor of which can instantly hide himself by a discharge of ink, is not pleasant even from a creature the size of a cat: but when it is remembered that some of them are six feet across, and that they do not kill quickly like the shark, but tear their prey piecemeal, we feel thankful to live in safer latitudes. In the *Hooked calamaries*, besides the hook-armed cups, there is a group of ordinary suckers, at the beginning of the expanded part of the tentacles. When these touch each other, they resemble the hinge of a pair of pliers, and the unfortunate beast hooked in between the flaps is drawn by the united strength of both arms to be torn to death at the top of the cuttle's head. It is a merciful provision that his great eyes, so necessary for him in locomotion and attack, are spared the sight of the tortures he inflicts upon his prey. The hooks

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\*The tentacle suckers of the calamary suggested the obstetric forceps of Prof. Simpson.

found fossil in the German Jurassic strata, with the traces of the cuttle itself, prove that the *Spiny calamaries* were equally the tyrants of the ancient seas. The *Sea-arrows* live in large groups in the open sea. They are themselves the prey of whales and birds. In order to avoid the attacks of their pursuers, they dart out of the water like the flying fish, often to such a height that they fall down on the decks of vessels. The eyes of these creatures have a deep lachrymal groove at the upper edge, and the ears are furnished with a longitudinal crest.

*Family* TEUTHIDÆ. (*Squids.*)

In the Squids the eyes are without lids, and covered with the skin, as in *Cranchia*; but the mantle is strengthened with internal cartilages, as in the *Sea-arrows*. The genera are *Gonatus*, *Loligo*, *Teuthis*, *Sepioteuthis*, *Rossia*, *Sepiola*, and *Fidenas*; with the fossil remains of *Leptoteuthis*, *Teudopsis*, *Beloteuthis*, and *Geoteuthis*.

The *Squids* form an important element in the North Atlantic fisheries. The common *Loligo* is the favorite food of the Cod, and is therefore itself fished for bait. One half of all the cod taken on the banks of Newfoundland are said to be caught by it. "When the vast shoals of this mollusk approach the coast, hundreds of vessels are ready to capture them, forming an extensive cuttle fishery, engaging five hundred sail of French, English, and American ships. During violent gales of wind, hundreds of tons of them are often thrown up together in beds on the flat beaches, the decay of which spreads an intolerable effluvium around." They must themselves be consumed in enormous numbers; for it has been estimated that a single squid will lay in one season forty thousand eggs. The pens of the squid tribe are loose supports in a pouch along the back. In old individuals, sometimes two or three are found laid together. They are analogous to the "bones" or steel plates in ladies' stays—an instrument which ought not to be needed by a vertebrated animal.

The *Sepiolas* are pretty little creatures, with round purse-like bodies, and a wing-like fin on each side. They live near shore, and may often be seen darting about in rocky pools. They are considered a delicacy in the South of France, where they are called *supieta*.

The squids first make their appearance in the world's history during the epoch of the Lias and Oxford Clay. The octopods may, indeed, have existed, but their bodies have no hard parts that would be likely to leave traces on the ancient rocks. Of the squids, not only the horny pens and claws have been preserved, but even the muscular mantle, the bottoms of the arms, and the ink bag filled with sepia which an artist might envy. They must have died a very peaceful death, as they always spill their ink under the slightest provocation. Some of the ink bags of the Lias are nearly a foot long, with a brilliant pearly coat. They probably formed part of the food of the formidable Ichthyosaurians of that epoch.

*Family* SEPIADÆ. (*True Cuttles.*)

The Cuttle-fish proper are furnished with a "bone," which consists, on the back, of a hard, shelly dish, covered with membrane and end-

ing in a knob, and built up within with layer upon layer of very delicate wafer-like shelly plates, supported by numerous vertical pillars.\* It is, therefore, very light and porous, at the same time that the shape and texture of the back give it great power of support. The cuttles are the least elegant of the tribe, having a large, flatish body, finned along the whole of each side. The knob, doubtless, protects the creature's tail from blows as it swims backward near the shore. The Chinese cuttle bones are sometimes eighteen inches long.

Most persons have seen the delicate *Spirula*, transparent and white, shaped like a ram's horn divided across by pearly chambers. A mere conchologist would never suspect any close resemblance between this and the cuttle-bone. They are, however, so closely connected by intermediate fossil forms, that, without a knowledge of their animal, it is difficult to say to which family these belong. No less different at first sight are the "thunderbolt stones," so common in the Jurassic and cretaceous rocks of Europe. In the world's history, they begin and end with these rocks. They were suddenly poured, in incalculable abundance, on our planet; and as suddenly they became entirely extinct. The

#### *Family* BELEMNITIDÆ

consisted of cuttles whose body was strengthened by a long pen, joining on, at the tail end, to a conical chambered shell, the air-cells of which were connected by a siphuncle at the side. This conical shell (formerly called the *alveolus* of the belemnite, and now known as the *phragmocone*,) was invested, at the tail end, with a longer cone or guard. This is fibrous, consisting of long prismatic cells, like the shell of the recent pinnas or the great cretaceous *Inocerami*, with which it entirely agrees in specific gravity. This guard is the "thunderbolt stone" of the common people, and is generally preserved entire, while the chambers are often destroyed, and the pen has almost always perished. The most perfect specimens were found in the Oxford Clay, and are preserved in the British museum and in the cabinet of Dr. Mantell. Fragments of the chambered part, in the Lias and Oolite, are very like the then-extinct orthoceratites, though the animal is widely different. The *last chamber* alone sometimes measures six inches by two and a half; so that its cuttle must have been nearly three feet long. A fortunate breakage, in a specimen in the British museum, displays an ink-bag near the siphuncle, at once showing that it was an active swimmer, like the cuttles. The length of the guard is very variable in the same species, sometimes attaining to two feet. The septa frequently perish, leaving the chambers, which have been filled with calcareous spar, lying loosely on each other like a pile of watch glasses.

The Belemnites were gregarious, and probably lived in a moderate depth of water. The classical writers before Pliny gravely supposed that they were the hardened contents of the bladder of the lynx;

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\*This substance, when reduced to powder, is called pounce. Among other uses, when rubbed on paper after "scratching out," it prevents the ink from running.

whence they bore the name *lyncurium*. The writers of the middle ages called them "ghosts' candles," "devil's fingers," "night mare's arrows," &c. The more learned supposed they might be petrified amber, fossil dates, stalactites, or spines of sea urchins. It was not till the beginning of the present century that their true nature was understood. The grooved *Belemnitella mucronata*, which is characteristic of the chalk and Upper Green Sand, is found on both sides of the Atlantic.

Although the Belemnite itself has not been found preserved, its next door neighbor, the *Belemnoteuthis*, has been discovered at Chippenham, (England,) with its shell, muscular mantle, fins, ink-bag, funnel, eyes, arms, and horny hooks, all complete, as if thrown by the tide upon our present shore. The hooks are formidable weapons, from twenty to forty pairs appearing on each arm. In this creature the guard is very thin. In *Conotenthis*, an active swimmer of the Neocomian age, we have a very long pen terminating in a phragmone shaped like a paper funnel; forming an exact transition from the Squids to the Belemnites.

#### *Family* SPIRULIDÆ.

The shells of *Spirula* are as common in tropical seas now, as were the *Belemnites* in those of the middle ages. Their resemblance to the pearly nautilus and other allied chambered shells, and especially to the fossil *Gyroceras*, or *Crioceras*, is very striking. Here is a loosely-coiled spiral shell, regularly divided by concave septa, like the Nautilus, each one pierced by a tubular siphuncle. But the resemblance is superficial only. The last chamber of the nautilus tribe is always large, and contains the animal, which is fastened to it by powerful muscles. Whereas the last septum of the *Spirula* is almost close to the margin, indicating that it is an internal shell, enveloped in the mantle of the cuttle-fish like the bone of the *Sepia*. Although the shell always forms part of the fancy collections from the Bahama Islands, and it is scattered by thousands on the shores of New Zealand, a perfect specimen of the animal has not yet been seen. It is, however, formed on the usual decapodous type; only the fins and arm-cups are very small. The ink-bag lies against the last chamber of the shell. Beautiful as the *Spirula* is, it is still more so when the outer coat on one side has been removed, by allowing it to float on dilute muriatic acid, so as to display the siphuncled septa.

Among recent shells, the *Spirula* stands by itself; but it is connected with the Belemnites and Squids by fossil forms. In *Spirulirostra*, from the Miocene of Turin, we have a very loose spiral siphunculated shell immersed in a kind of cuttle bone of irregular shape. In *Belloptera*, a fossil of the Nummulite age, the chambered part is nearly straight, and surrounded by a "bone" formed by two inverted cones with winged-processes between. In *Belemnosis*, a unique fossil of the London Clay, the bone is not winged. In *Helicerus*, a fossil described by Professor Dana from the slate rocks of Cape Horn, there is a guard, as in the Belemnites, inclosing a chambered shell somewhat spiral at the nucleus.

## ORDER II. TETRABRANCHIATA,

or *four-gilled* cephalopods, of Professor Owen. It might be thought a matter of little importance whether a cephalopod had one or two pairs of gills; but it happens that this difference is coördinate with others that run through the whole form and structure of the animals. The two-gilled cuttles, we have seen, are adapted for an active and predacious life. As they could not dart after their prey carrying a heavy shell, they are naked, but furnished with powerful arms and ink-bag for their protection. The four-gilled tribes, on the other hand, are destined for a quieter life, crawling on the ground like common Gasteropods. Instead of eight or ten arms with suckers and hooks, they have a multitude of small retractile feelers, something like the Sea Anemone. On these they can creep, and draw their prey to their mouths; but they are not able to pursue it in the open sea. Instead of a strong breathing tube with a valve, answering the purpose of a forcing pump and propeller, they have only an open gutter made by a fold in the mantle, like the siphons of the Gasteropods. The eyes, which in the cuttles have optic ganglia much larger than the central brain, (*Alcock*,) are here less conspicuous, and mounted on peduncles. The head and tentacles, instead of being the principal part of the creature, to which the body might appear subordinate, are here scarcely separated from it, and retractile within the general mass. They are always furnished with a chambered shell, the last cavity of which contains the animal. When disturbed, instead of squirting ink and darting off, it shrivels up into its cavity and takes its chance. If it sees a delicate crab at a distance, instead of pouncing on it, it must crawl, not, indeed, on "all fours," but on "all dozens;" or wait until the creature comes within seizing distance, when it will be entangled in the arms and be broken up by the jaws or gizzard.

Only one animal formed after this type is now known to be living on the earth; the *pearly* or true *Nautilus*, whose many-chambered shell has been an object of admiring speculation from early times. This is the last straggler belonging to a race which performed important functions in the early ages of our globe. The *Nautili* themselves are among the few genera which have existed at every period of the world's history. Our knowledge begins with one species from the upper silurian rocks of Bohemia. It has not culminated at any particular period; not more than seven species appearing in any formation; but it has never been without its representatives, and two or three species are now crawling on the sea bottoms in the East Indian archipelago. Before them, however, lived the great *Orthoceratites* of the palæozoic seas; and as they died out, the great family of the *Ammonites* developed themselves, and held possession of the seas till the close of the cretaceous period, when they suddenly disappeared, leaving not even a distant relation to grace the tertiary formations. Coördinate with the prevalence of four-gilled Cephalopods, we find a general absence of the predacious Gasteropods which are now so numerous and highly developed. We may suppose, therefore, that they played the same part in the economy of nature; and that the *Orthoceratites* and

*Ammonites* did the work of destruction in ancient times, which is now performed by murices, strombs, whelks, and their allies.

The chambered shell is always pearly within, but with an external porcellanous layer. The Chinese are fond of leaving patterns carved on the *Nautilus* while the body of the shell is uncoated, to show the nacre. In fossils sometimes the outer coat has perished, sometimes the inner, and sometimes both. The chambers are always connected by a siphuncle, through which the animal maintains a connection with the deserted chambers. These are lined with a very thin living membrane in the *Nautilus*; in the *Orthoceratites* they show the marks of blood-vessels, &c., which prove that they played some unknown part in the economy of the animals. That these air-chambers serve as a float, to balance the weight of the shell and enable the creature to swim if needful, cannot be doubted; but the stories of their filling the cells with air or water at pleasure, and so sailing at the top or descending to the bottom, appear to be fables, like the classical legends of the Argonaut. The living *Nautilus* only comes to the surface occasionally, when the sea bottom has been agitated by storms; and it is believed that the fossil species inhabited depths not greater than thirty fathoms. The chambers are filled with nitrogen gas, without oxygen or carbonic acid. The animal is attached to the shell by powerful adductor muscles. As these grow onwards, the animal gradually deserts the last chamber; and, at periodic periods of rest, a fresh septum is formed.\*

If a diving bell had explored what is now called New York and

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\*The following lines have the rare merit of not losing truth at the same time that they are highly poetical. They are copied from the "Atlantic Monthly." Let the reader take in his hand a pearly *Nautilus* cut through the middle, and say—

This is the Ship of Pearl, which, poets feign,  
Sails the unshadowed main;  
The venturous bark, that flings  
On the sweet summer wind its purple wings,  
In gulfs enchanted, where the siren sings,  
And coral reefs lie bare;  
Where cold sea-maids rise, to sun their streaming hair.

Its web of living gauze no more unfurl;  
Wrecked is the ship of pearl!  
And every chambered cell,  
Where its dim, dreaming life was wont to dwell,  
As the frail tenant shaped his growing shell,  
Before thee lies revealed;  
Its irised ceiling rent, its sunless crypt unsealed!

Year after year behold the silent toil  
That spread his lustrous coil;  
Still, as the spiral grew,  
He left his past year's dwelling for the new;  
Stole, with soft step, its shining archway through;  
Built up its idle door,  
Stretched in his last-found home, and knew the old no more.

Canada when they lay at the bottom of the palæozoic seas, it would have encountered multitudes of long pointed shelly cones, floating upright in the water, some of them adorned with beautiful colors and sculpture, and slowly moving among the corals, sea-weeds, and stonellies which then adorned the gardens of the great deep. They belonged to the

*Family* ORTHOCERATIDÆ,

or *Straight-horns*. Some of them carried on their backs the largest shells that ever lived. A specimen belonging to Col. Jewett, of Albany, now measures twelve feet, and when perfect must have been fifteen feet in length. And yet, from the buoyancy of its contained air, the comparatively feeble cephalopod could maintain its enormous leverage, and crawl on its slender tentacles. The aperture of the *Orthoceratites* is generally contracted, and the head was perhaps always exposed. The siphuncle is very large, and in some of the genera very curiously formed, indicating much more vitality than in the corresponding part of the *Spiral Nautilus*. This was necessary in order to maintain a living connection at such a distance from the body. All the orthoceratites have simple, concave chambers, with a central opening. They disappear at the beginning of the secondary rocks, leaving their work to be performed by the huge *Ammonites* of the Lias. In *Gonioceras*, the shell is flattened, and the septa waved. In *Actinoceras*, *Hormoceras* and *Huronia*, the siphuncular processes are enormously developed around the central tube, according to different patterns. In *Thoracoceras* and *Cameroceras*, the siphuncle is marginal, and generally small. The strange fossils called *Endoceras* by Prof. Hall have very long slender shells, with a large cylindrical siphuncle, somewhat lateral. This is thickened internally by separate layers of shell, or funnel tubes one inside the other, called "embryo tubes" by the author, contrary however to all analogy. Their use may have been to give increased strength in consequence of the great elongation of the shell. Some of the species appear to have been constituted from the accident of a young shell being lodged in the siphuncular cavity: others from the monstrous formation of a second siphuncle.

Thanks for the heavenly message brought by thee,  
 Child of the wandering sea,  
 Cast from her lap forlorn!  
 From thy dead lips a clearer note is borne  
 Than ever Triton blew from wreathed horn!  
 While on mine ear it rings,  
 Through the deep caves of thought I hear a voice that sings:—

"Build thee more stately mansions, O my soul,  
 As the swift seasons roll!  
 Leave thy low-vaulted past!  
 Let each new temple, nobler than the last,  
 Shut thee from heaven, with a dome more vast;  
 Till thou at length art free,  
 Leaving thine outgrown shell, by life's unresting sea!

The *Phragmoceras* and *Oncoceras* form a sub-family, in which the shell is pear-shaped and contracted at each end.

The bent forms constitute another sub-family, and were perhaps more nearly related to the Nautilus. *Cyrtoceras* is slightly curved, and shaped like a gigantic Cæcum.\* *Gyroceras* develops a shape like *Spirula*; and *Ascoceras* displays a shell bent upon itself, like *Ptychoceras* among the Ammonites.

#### Family NAUTILIDÆ.

In the living Nautilus, the only interpreter of the great group of Tentacular Cephalopods (as D'Orbigny calls the order) the horny beaks are surrounded with shelly matter, giving them great crushing power over the shells of crustaceans. Similar beaks have been found fossil in various strata, associated with Nautili. In the Muschelkalk of Bavaria, where there is only one species of Nautilus, the upper beak has been described as *Rhyncolites hirundo*, and the under beak as "*Conchorhynchus avirostris*." D'Orbigny has turned these mandibles into cuttle bones, under the names of *Rhyncoteuthis* and *Palæoteuthis*; one out of the many instances in which a knowledge of comparative anatomy is shown to be essential to the study of organic remains. Round the mandibles is a circular fleshy lip; round which again are about four dozen labial tentacles, answering to the "buccal membrane" of the cuttles, and serving to bring the prey to the mouth. Beyond these are a double series of tentacles, thirty-six in number, answering to the ordinary arms of the cuttles. When the creature is expanded for crawling or seizing prey, these would project somewhat in the form of a figure 8, the mouth being between the two groups of tentacles. When the creature retires into its shell, it protects the opening with a hood, which answers to the back pair of arms, united together and developed for that purpose, as are one pair in the female Argonaut to envelop the shell. The tentacles shut up in bunches into sheaths, which correspond to the eight common arms of the cuttles. Besides these there are four tentacles, one on each side of each eye: these appear to be feelers as in the Gasteropods. It is easy to see how much more highly organized and active is the *paper*, than its distant relative the *Pearly* Nautilus. In each case, all the animals examined have been females. It has been supposed that the shell-forms with a wide opening at the axis of the spire, belong to the males, which, as in the other Cephalopods, are few in number. Similar differences are found in almost all the Ammonites.

The Fossil Nautili present several sections, differing more or less in type from the recent species. In *Cryptoceras*, the siphuncle is nearly external, as in the Ammonites, which it resembles in external form. In *Tennocheilus*, the shell is carinated. In *Discites* all the whirls are exposed and flattened. These sections are from the palæozoic rocks. The "*Ellipsolithes*" were simply Nautili and Ammonites which had been accidentally compressed into an oval shape.

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\*The *Corniculina* figured by Munster as a chambered shell, is probably only a badly observed Cæcid.



In the *Lituities* of the ancient seas, we have a *Nautilus*, which, on coming to maturity, produced its tube in a straight line. The *Hortolus* resembles it, but with the whirls separate as in *Spirula*. In *Trochoceras*, we find the spire more or less elevated, as in snails.

The sub-family CLYMENIDÆ consists of forms in which the chambers are more or less waved or indented, forming a slight approach to the Ammonites. They are all palæozoic forms, except *Aturia*, which makes its appearance unexpectedly in the London Clay. This has a very large internal siphon, like a number of funnels interwrapping each other, and reminding us somewhat of *Endoceras* among the Orthoceratites.

*Family* AMMONITIDÆ. (*Ram's-Horn Shells.*)

This group, so abundant in the middle ages both in species and in individuals, suddenly passed out of existence at the close of the cretaceous age. The body of the Ammonites was long in proportion: the opening of the shell was guarded by curiously-shaped processes, and closed by a double operculum. In the beautiful flat Ammonites of the Oxford Clay, the shell makes two long forceps-shaped beaks, one on each side of the mouth. In another species, these beaks arch over the mouth and meet in the middle, leaving one hole for the head to crawl out at, and the other for the opercle-bearing arms. In other species, the aperture is almost closed up, as in many snails.

In the keeled species, the operculum was of one horny piece, as in Gasteropods: but in the round-backed groups, it was shelly, and divided into two plates. Forty-five kinds have been described, one being from the palæozoic rocks. They were called *Trigonellites* by the old writers, and doctors still disagree as to their nature. D'Orbigny thought them cirripedes: Meyer, bivalve shells: Sowerby, fish palates: Deshayes, gizzards of Ammonites: Coquand (followed by Chénu) cuttle bones. They have however sometimes been found in situ, exactly answering to the hood of the *Nautilus*.

But the most remarkable character of the Ammonites is the *sutures*, or edges of the chambers. When an Ammonite is sliced down the middle, the septa simply appear waved as in *Clymene*. But when the outer shell is removed, and the cast of the edges is displayed, we find a beautiful leafy structure, often of very intricate pattern, but constant in each species. The siphuncle is always external. The outside is almost always very beautifully ornamented, with ribs, knobs, spines, or delicate striæ. The under layer is always pearly, as in *Nautilus*; and beautiful objects they must indeed have been, when painted with various colors and patterns, to those who could have seen them with oolitic or cretaceous eyes. Some of them are of enormous size, measuring occasionally two feet in diameter. These are found in the Lias, and in the neighborhood of Bristol (England) may often be seen built into the walls by the road side. More than five hundred and thirty species are already known. They are rare in America, but very common in Europe. Species, similar to those of the English oolite, have been found in the high passes of the Himalaya, more than 16,000 feet above the level of the sea.

The most ancient of the tribe are the *Goniatites*, of the Upper Silu-

rian and Carboniferous seas. In these, the sutures are not foliated, but simply lobed, often at sharp angles. In the *ceratites* of the Muschelkalk series, the alternate lobes are denticulated. The *Goniatite*, when the spire is unrolled into a straight cone, like the *Orthoceratites*, becomes a *Bactrite*; and the *Ceratite*, similarly unrolled, becomes a *Baculina*.

The true *Ammonites*, with minutely lobed septa, present all varieties of shape; from the compressed forms, with the whirls scarcely touching, to the involute species, with round backs, narrow chambers, and very small umbilicus. They have been variously divided into groups by different authors; but they pass into each other by very slight distinctions. Often a shell, which in its earlier stages would belong to one group, develops into a different one as it approaches maturity.

The *Ammonites* present various aberrant forms, some corresponding to those already mentioned among the *Nautili*, some peculiar to themselves. In *Crioceras* the whirls are separate, as in *Spirula*. In *Scaphites*, the shell begins like an *Ammonite*, the mouth is next produced at a tangent, and then bent back upon itself. It would be curious to know how such creatures got their living. *Ancyloceras* combines the characters of the two last genera, beginning as *Spirula*, and ending as *Scaphites*. *Anisoceras* has the same form, but drawn out of the plane into an irregular spiral, like *Vermetus*. *Toxoceras* presents a simple cycloidal curve. In *Hamites*, the shell begins quite straight, then bends and returns again parallel to itself, and so on, like a *Spirula* drawn out and flattened on its two sides. In the section *Hamulina*, the shell only makes one bend, the two parallel limbs having different sculptures, and the body-chamber occupying one limb and the elbow. The *Ptychoceras* is like a *Hamulina*, with the two limbs joined together; still with different sculptures, so that fragments might easily be described as distinct species. In *Baculites*, the shell is quite straight, like a walking stick. It is so common in the Normandy chalk as to give it the name of *Baculite Limestone*.

In the *Terrilite* group, we have an approach to the ordinary shape of the univalve spiral shells. They are mostly reversed, and are supposed by Woodward to have had one pair of gills atrophied. In *Heteroceras*, after beginning as a *Turrilite*, the shell becomes separate, as in the adolescent *Vermetus*, and makes an irregular spire enveloping, but not touching, the spire. The *Helicoceras* is as it were a *Turrilite*, with all the whirls drawn out into a corkscrew.

We have now enumerated the principal known forms of *Cephalopods*, both extinct and living. While they are the most highly organized of invertebrates, they cannot be considered as *typical mollusks*; that is, they do not represent the idea of molluscan life, as do the ordinary *Gasteropods* which we have next to consider. Now those classes which go off from the standard idea are generally pretty well defined; while those in which the normal idea culminates are more variable in structure. We have seen that the *cephalopods* are all formed on two well-marked but distinct types; and however much the shell of the *Baculite* may differ from the *Nautilus*, or the Argonaut's egg-case from the cuttle-bone, a beginner even could never doubt con-

cerning the class of a cephalopod if he saw it alive: for though starfish and polypes, as well as Bryozoa, have a central mouth surrounded by arms or feelers, the great eyes and funnel, as well as the soft but muscular body, would at once assign its position. It is not so with the Gasteropods. To say nothing of the different shapes of the shell, as e. g. in *Chiton*, *Dentalium*, *Patella*, *Trochus*, *Vermetus*, *Cypræa*, *Murex*, and *Carinaria*, the shapes of the animals are so very unlike that even now naturalists are not agreed as to the limits of the class; still less on the arrangement of its fundamental divisions; least of all, on the position of particular families and genera. This should by no means discourage the student; but on the contrary fill him with zeal to prosecute a study in which so many unworked materials are within his own reach; and in which, therefore, instead of merely following at a remote distance in the steps of the learned, he may, without neglecting the main duties of his life, add materially to the stores of human knowledge, and even throw important light on the dark places of our planet's ancient history.

### CLASS GASTEROPODA;

that is, *belly-footed* animals, or *crawlers*: comprising *snails*, *periwinkles*, *whelks*, *limpets*, and "univalve shell-fish" generally.

These creatures form three-fourths of the whole number of mollusks. They inhabit sea-shores, and the sea-bottoms, down to the lowest depths of ordinary animal life: they are found swimming in the open seas, or accompanying the floating gulf weed: or they live in fresh waters, crawling on stones or aquatic plants. Lastly, they are found on dry land, in all kinds of situations where lime exists; either in damp and marshy places, or in rocky deserts; either burrowing in earth or crevices, or creeping on the vegetation of forests, herbage, or lichen-covered stones. One cannot live anywhere, therefore, where crawling mollusks are not within our reach. The following classification may aid us in understanding these many-shaped creatures:

Class.	Sub-classes.	Orders.	Examples.
<b>GASTEROPODS.</b>	PROSOBRANCHS. ...	PECTINIBRANCHS. ...	Whelks, Cones, Strombs, Cowries, Periwinkles.
		SCUTIBRANCHS. ....	Limpets, Chitons, Sea-ears, Topshells.
		CIRROBRANCHS. ....	Tooth Shells.
	PULMONATES. ....		Snails.
	OPISTHOBRANCHS. ...	TECTIBRANCHS. ...	Bullas, Sea Hares, Umbrellas.
	NUDEBRANCHS. ....	Doris, Eolis, &c.	
	NUCLEOBRANCHS. ....		Carinaria, Janthina.

In the PROSOBRANCHS, the breathing cavity is at the back of the head, *in advance of the heart*. There is always a distinct shell, which generally covers the animal. They form two principal groups, (1) the *Pectinibranchs*, in which the gill is comb-shaped, and the animal unisexual: and (2) the *Scutibranchs*, in which the gills are in plates, like the bivalves, and the animal has the sexes united. The *Cirrobranchs* are a small and very aberrant group.

In the OPISTHOBRANCHS, the gills are *behind the heart*, and very variable in position and structure. There is no shell, except in a few families of the *Tectibranchs*, in which the gills are covered by the

mantle. In the *Nudibranchs*, they form ornamental excrescences, more or less diffused over the body. The sexes are always united.

In all the water shell-fish, the animal after birth undergoes a metamorphosis, as in the insect tribe, before it assumes its normal condition; but in the intermediate tribe of SNAILS, the creature is born into its proper shape. The sexes are united, as in the Opisthobranchs.

The NUCLEOBRANCHS have the gills in a tuft at the lower part of the back, sometimes protected by a shell. They do not crawl like true Gasteropods, but are an aberrant group passing over to the Pteropods. They swim in the open sea; and while they devour the jelly-fish, are themselves the prey of true fishes and cuttles.

#### ORDER PECTINIBRANCHIATA. (*Comb-gilled Crawlers.*)

All these creatures have a spiral body, guarded by a shell. When they walk about, the liver and other viscera remain in the upper portion of the shell: but a large fleshy foot is protruded, on which the animal crawls; as also the head, with a distinct neck. On the head are a pair of tentacles, (commonly called "horns," from their similarity of position with the cow's horns,) which are extremely delicate organs of sense. The eyes are on these, or at their base; or, sometimes, on little eye-stalks near. In front is the snout, which is either short, as in the periwinkles, or produced into a long trunk, as in the carrion-feeding Strombs. Sometimes it appears very short and innocent; but really it has swallowed, and can at any moment dart out, an enormous proboscis, armed with powerful rows of teeth. The bottom of the shell is in reality its front; for there the animal breathes; there being either a pipe or a hole to let the water-current in to the gills. The alimentary canal is doubled back over itself, terminating near the gills, so as to be able to act, when the creature is at rest in his shell. There are seldom any differences observable in the shells of the two sexes. The intromittent organ is near the head, and generally very long; varying considerably in shape in the different genera. At the end of the foot is a horny *operculum* or toe nail; which is drawn in last of all into the shell, and serves to close its aperture, like a trap-door.

Remembering that the shell is part and parcel of the living animal—a secretion from its muscular skin or *manile*—of truly organized structure, though not endowed with feeling; we shall naturally expect to find differences in the shell corresponding with those in the sentient inhabitant. This is generally, but not always, the case. Lamarck thought that all creatures with a round-mouthed shell were herbivorous, and all those with a notched mouth carnivorous; but now it is known that some round-mouthed groups are very fierce, as *Natica* and *Scalaria*, while some that were thought predacious, as *Cerithium*, are vegetarians. In *Melania* and *Io*, *Bulimus* and *Achatina*, we have both forms of shell in one family. So Clark imagined that all creatures with many-whirled opercula were hermaphrodites; all with few whirls unisexual. But the hermaphrodite *Nerites* have few whirls; while *Modulus* among the Periwinkles, and *Cerithidea* among the Cerites, differ from the other members of their unisexual families in having

many whirls. The study of mollusks is calculated to warn any student against hasty generalizations. He is continually finding characters important in one family, which prove of little moment in another: marks which he has long rightfully considered coördinate with special distinctions, appearing again in quite different connections, as well as essential differences of animal appearing, where there was nothing in the shell to lead to their suspicion. An artificial classification, therefore, however convenient as an *index* to characters and species, does not convey that knowledge of the whole relationships of the animal, which we ought at least to seek to express. It is to be regretted that some of the most learned of modern writers have gone on this artificial plan; and, from a determination to be guided by certain special characters as fundamental, have grouped together very unlike creatures, and separated others with natural affinities, to the great perplexing of beginners. Thus, in the arrangement followed at the British Museum, the Gasteropods and bivalves are grouped together, simply because they have a foot; and the Lamp-shells, Pteropods, and Cephalopods together, because they have none: the noble Cuttles being degraded to the lowest rank among mollusks; and two closely allied classes of bivalve shells, as well as the nearly related Gasteropods and Pteropods being separated in the primary division, simply because they have or have not a *foot*—a character which varies to the greatest extent within each separate class; for many of the Heteropods among the crawlers have not so much of foot as the cuttles, and the oysters among the bivalves have none at all. The same grouping, according to individual characters, prevails throughout the subordinate divisions. But there is a difference between a *classification* and an *index*. The Linnæan grouping of plants is an admirable *index*; by consulting which an unknown flower may be at once put into its proper place; but it tells very little, and that little often erroneously, of the true relationships of plants. The "Natural System" is much harder to learn, and requires constant alterations; but, so far as it is ascertained, it is a compendium of the existing state of science. So the British Museum method is an admirable *index*; for a student, having a fresh animal under examination, can at once arrange it under its appropriate "Suborder, Tribe, A, a, \*, †," &c.; but whether he is showing, or upsetting its true relationships by this process, is yet to be seen. It was thought in the days of Lamarck that animals, if fully known, might be arranged in a straight line, gradually ascending from the monad to man. Every progress in our discoveries impinges upon this idea, and shows that we cannot even arrange by radiations or circles in one plane. We have to branch off into space, like the suns in the universe: the attractions of each, with its attendants in orbits of different planes, being to every other. To express this in a superficial way on paper must needs only give us partial impressions, which nothing but patient study can develop into even an approximation to the truth.

The comb-gilled crawlers very naturally divide themselves into those with a long retractile proboscis, which can be drawn into the mouth or extended at pleasure; and those with an external muzzle, more or less produced into a snout. The first group are all preda-

cious, rasping the flesh or sucking the juices of other mollusks, crustaceans, or zoophytes. The second group are variously organized, according as they scour the shores for carrion, browse on the sea weed, or are satisfied, like the bivalves, with the organic matter that the sea wafts to their mouths. In each group we find creatures of equally high organization, as *e. g.*, the whelks and strombs; in each, some very low, as *Magilus* and *Vermetus*. As a general rule, the operculum in the predacious group is in concentric layers; in the vegetable-feeders, more or less spiral in its growth.

GROUP PROBOSCIDIFERA. (*Crawlers, with Retractable Proboscis.*)

All these creatures are able to swallow their snouts and their tongues. They have sharp tentacles, with the eyes generally placed on knobs, part way up their sides. They have thin necks; and, when not hungry, appear very innocent, as well as graceful creatures, the dangerous organ being quite concealed. Their foot is large, flat, and spreading, more separate from the body than in the snails. But when their hungry or ferocious instincts are aroused, they dart out a long trunk, sometimes even longer than their shell, at the end of which are various drilling teeth, so arranged that they can bore a hole, even in the strongest shells, and suck out the unfortunate inhabitant. Every one must have observed these accurately turned holes, especially near the hinge of bivalve shells. Besides this drill-bearing trunk, they have a long horny tongue, or "lingual ribbon," armed with hundreds of teeth, arranged in various patterns, which differ in the various families. These tongues, when at rest, lie coiled up in a cavity near the stomach. They do not make such quick work with their prey as do the cuttles. Fancy the condition of an unfortunate clam or mussel, resting peaceably in his bivalve shield, as he hears a grating noise, outside his liver, going on hour after hour, he knows not why. At last he feels the drill, and then the horny tongue, entering his vitals, and he is sucked out of existence without possibility of defense!

The shell of the Trunk-bearers may almost always be known by a notch or canal at the base; the object of which is to protect, or at any rate allow the egress of the breathing pipe, which, as in the *Nautilus*, is an open gutter formed by a lengthening and folding of the mantle. In most of the tribe the trunk is drawn in base foremost; but in the aberrant group of Cowries, Dr. Stimpson has observed that the tip is first swallowed. In another group, of which the Cones are the type, there is said to be no separate tongue; but the teeth are inserted, in two rows of organs like the sting of a bee, in the substance of the trunk itself. The predacious *Pectinibranchs* are arranged according to the form of teeth on the tongue-ribbon.

Foremost in rank and beauty among the Gasteropods, stands the

*Family* MURICIDÆ,

or Rock-shells, in which the lingual ribbon is long and narrow, with a multitude of very small teeth arranged in rows of three, (1·1·1,) each of them with several spikes. The middle row only is fixed. In *Murex*

proper, the animal, as it increases in size, periodically produces beautiful foliations or *varices* from its mantle, at least three on each whirl. In the typical species these are thin, light, and armed with numerous, often very long spines; and the canal which holds the breathing siphon is greatly produced, nearly closed, and also armed with spines. One would think the animal would be as much incommoded by its splendid dress as a fashionable lady in a crowded ball-room. As the animal grows, it eats away the last year's varix, which would otherwise close up the aperture. It often happens that old mollusks, either to lighten the weight they have to carry on their backs, or from becoming more portly inside, eat out part or the whole of the interior partitions in the same way. If the spire is long, or they are attacked by borers in the upper region, where the liver works, they also have the power of partitioning off the unused or diseased part by septa, which, however, are not regular or perforated as in the Nautili.

When the shells are strong, and the varices numerous and foliated, they are called *Phyllonotus*. They are very numerous and beautiful on the west coasts of tropical America and Africa. The shells of *Pteronotus* have a few wing-like varices. When these are feebly developed, as in *Muricidea*, they pass into the next genus, *Trophon*, where the varices have degenerated into mere raised laminae. This is an arctic form, both of the northern and southern seas. The *Typhis*, which appears first in the older Tertiaries, is a *Murex* with a single open spine between the varices. This is supposed to perform the function of an excurrent canal, like the slit in *Pleurotoma*, or the hole in *Vissurella*. Another group, of which the Spindle-shells are the type, has no varices at all; but both the spire and canal are greatly elongated. The true *Fusus* is a tropical form; but an intermediate group, with moderate canal, (*Chrysodomus*), abounds in the arctic seas. The *Chrysodomus antiquus*, still common in the British seas, and found in the whole circumpolar region of the North, was equally common in the various tertiary epochs of the English Crag. A reversed variety ("*Fusus contrarius*") was the characteristic species of the Red Crag, and is now found living, beyond the limits of the normal form, in the Mediterranean and on the coast of Spain. The Scotch call it the "roaring buckie," from the "sound of the sea" which the air makes along the spiral passages when held to the ear. The Zetlanders hang it flat, put a wick in the canal and oil in the body whirl, and make a lamp of it. It is now fashionable to suspend the great Turbo in the same way as a flower vase. The *Clavellas* have curiously deformed mouths, and abounded in the Eocene age.

Lamarck, knowing little of the animals, divided his families according to the length of the canal; but this is no index to the length of the siphon. In the *Pisania* group, the canal is very short, but the siphon is moderately long and curled back over the shell in walking. A tooth on the body whirl, marking off the top end of the mouth, shows the position of the excurrent canal. The *Enginas* are little shells with wry mouths, about which very little is known, though they are very common on both shores of tropical America.

As *Pisania* represents in this family Lamarck's *Purpurids*, so *Cominella* and *Metula* represent his *Buccinids*. They are in fact *Buccinums*

with a Muricoid operculum. Their favorite haunts are the rocky shores of South Africa, Australia, and New Zealand; *Metula* being an American and East Indian group.

In the same way *Anachis* represents the *Columbellas*; from which the shell is known simply by having a more elevated spine and transverse ribs.

#### Family BUCCINIDÆ. (*Whelks.*)

The genus *Buccinum* of Linnæus contained all the shells with a notched base: a heterogeneous group, most of which have been moved off, step by step, to other families and genera; leaving only a few species, mostly from the boreal seas in each hemisphere, to keep up the ancient family name. The Whelks are very closely related to the Murices, from which they differ chiefly in having a thin, oval operculum, with the nucleus a little out of the centre. The true *Buccinum* has a notch for the breathing tube, and *Strombella* (a shell common in the Norwegian seas, but still so rare near England that good specimens sell for ten dollars) a short canal. The *Columbellæ*, which are very pretty little shells, extremely abundant in both oceans of tropical America, are still but little known in their economy, but belong by operculum to this family. They have their mouths so twisted by teeth, that the foot and operculum has to go in and out sideways. Perhaps this accounts for the operculum being so often broken and abnormally repaired. It is a curious fact that whatever be the form of the operculum in the different tribes of predacious mollusks, whenever it has been broken and has to be repaired by the animal, it always takes a simple oval shape with concentric layers, the nucleus being in the middle. In one place on the English coast there is found a race of *Buccinum undatum* (the common whelk of the English and American coasts) which perpetuates a very abnormal condition. They have two small opercula of more or less irregular shapes, but each of concentric elements. Probably their remote ancestor met with an accident, and has transmitted her mode of repairing the fracture to her descendants.

#### Family PYRULIDÆ.

The shells of this group run into those of *Fusus* by insensible gradations; but the animals present a well-marked difference. The neck (not the snout, as in the Strombs) is very long, the proboscis being still further extensile. The head and tentacles are small in proportion. Many of these shells are very large. The *Pyrula melongena* and *P. patula*, inhabiting respectively the Atlantic and Pacific shores of tropical America, are eaten by the natives. In the genus *Hemifusus* are two of the largest living Gasteropods, the *H. colosseus* and *proboscidalis* of the East Indies.

#### Family PURPURIDÆ.

The animal of *Purpura* differs very little from that of *Buccinum* and *Murex*; but the operculum is formed on a very peculiar plan. Outside



it looks shapeless, like a chip of rosewood; within, however, it is seen that it has been formed on the usual concentric plan, but with the nucleus elongated, and turned towards the outer lip of the shell. The name of the principal genus is derived from a crimson dye which many of the species exude when pressed. It was not, however, from these, but from the *Murex brandaris* and *M. trunculus* of the Mediterranean, that the ancients obtained their celebrated Tyrian purple. Cavities in the rocks, with heaps of the broken shells, where the mollusks were sacrificed to dye the robes of the nobles, are still seen on the shores of the Morea and Levant.

The shells of this group reproduce many of the forms of the Muri-cids, but with the chip, instead of the claw-shaped operculum. Thus *Cerastoma* has regular varices like *Murex* and *Vitularia*; irregular ones like *Trophon*. *Rhizocheilus* has generally been confounded with *Muricidea*. *Chorus* presents the shape of *Chrysodomus*, and *Rapana* of *Pyrrula*. *Iopas* takes the place of *Pisania*; the wry-mouthed *Ric-nula* of *Engina*; and *Nitidella* represents *Anachis* and the *Columbellas*. The true *Purpura* has a peculiar scooping out of the pillar-lip. This, when exaggerated, and at the same time the body whirl greatly enlarged at the expense of the spire, produces the common *Concholepas* of the Peruvian coast, which at first sight might be taken for a limpet. In *Monoceros*, a genus almost peculiar to the west coast of America, and ranging from California to Cape Horn, a sharp spine is developed at the base of the outer lip. The same is seen in *Chorus*, *Cerastoma*, and *Concholepas*; and may be looked upon as a west American peculiarity.

In the *Rapana* group, *Melapium* represents the *Pyrrula melongena*, and the delicate *Rapa* shells the *Ficulas*. The *Pseudoliva* is clothed with a coarse epidermis, and has a channel running spirally outside the base of the shell, the use of which is not known. In the angular *Cuma tectum* and in *Purpura columellaris*, there is a hump which runs along the middle of the pillar lip.

The purple-shells frequent rocky shores all round the globe, and are generally very prolific. They feast on bivalves, periwinkles and other shell-fish. Some of them are very sedentary in their habits, especially the *Rhizocheils*, which clasp round the stems of corals and prey upon the Polypes. These often have the breathing canal almost rudimentary.

The *Magilus*, which used to be considered an Annelid, and afterwards a Vermetid, is perhaps a degraded member of this group. When young it has a white, globular shell, shaped like *Natica*. It establishes itself among the Red Sea Polypes; and as the corals grow upwards, so does the *Magilus*, forming a solid, irregular tube, with a keel to represent the canal. *Leptoconchus* resembles its young state, but with a slight notch, and no operculum. The *Magilus*, having plenty of lime to eat, fills up its spire and the forsaken part of its tube with solid shelly matter.

#### Family NASSIDÆ. (*Dog-whelks*.)

The *Nassas* have small, compact, highly sculptured shells, with a sharply twisted notch, through which the long curly siphon protrudes. There is generally a strong lump on the inner lip. The animal has

two slender tails at the end of its foot, and a very thin, horny, triangular operculum, very finely serrated on each side. When the operculum is reproduced after injury, very few serrations are formed. In the *Phos* group, there is only one tail, the eyes are very near the tips of the tentacles, and the operculum is claw-shaped, without serrations. The animal and even the operculum is as yet unknown in many of the genera and most of the species of this group: and it is probable that the family will need considerable revision.

In *Bullia*, a genus which delights in southern peninsulas, the foot is extremely large, giving a glossy coat to the shell, and the animal is blind. It probably plows the wet sand for bivalves, like *Natica*. The *Pseudostrombs* form a transition between these and the ordinary forms, not having any gloss on the spire. The true *Nassas* are active burrowers, curling their nose-pipe up through the twisted notch, while they search the sand for bivalves. They are extremely abundant in tropical seas, both in species and individuals. In *Desmoulea* the shell is rolled up almost into a ball; and in *Cyclops*, it is curiously distorted and flattened like a Nerite. Several of the shells called *Nassas*, as the common "*Buccinum obsoletum*" of the west Atlantic, and *Nassa panamensis* of the east Pacific, have a Pisanoid operculum. They perhaps belong, with *Northia*, to the *Phos* group. The *Phos* shells are very beautifully cancellated: they have a sharp plait near the breathing notch, and a wave at the base of the outer lip. *Nassaria* represents the Tritons in this family, and *Cyllene* the Volutes.

The *Eburnas* are very beautifully spotted shells, strong, solid, and more or less shining. They are always smooth, and rarely display any epidermis. They form a transition to the Harps.

#### Family PUSIONELLIDÆ.

This little group has shells like *Fusus*, but the operculum is sub-triangular, with the nucleus on the inner margin.

#### Family TURRICULIDÆ,

These creatures would be taken for *Mitras* from the shell alone. Indeed the only characters by which the shells can be distinguished are the trifling ones that they are externally ribbed transversely, and the outer lip furrowed within; characters which in other groups would only amount to specific difference. Here, however, they are coördinate (so far as yet observed) with important characters in the dentition; the true Mitres being toothed like *Fasciolaria*, which will be presently described; while the *Turriculæ* agree with *Murex*.

In the remaining family of this group, the foot is greatly developed, causing a more or less glossy secretion over the whole shell.

#### Family OLIVIDÆ. (*Olives and Harps.*)

When the foot is very large, we often find the operculum very small or absent. In the Harps and Olives, the foot is deeply chiseled on each side of the front; so as to make lappels, which may be doubled up over

the head to protect it as it burrows in the sand. There are three divisions in the family, of which the types are *Oliva*, *Ancilla* and *Harpa*, and are thus characterized :

**OLIVINÆ.** Shell compressed, smooth : pillar plaited : suture channeled : a tail from the side of the mantle occupying the groove.

**ANCILLINÆ.** Without shell channel and mantle tail.

**HARPINÆ.** Shell ventricose, with varices pointed at the suture.

The Olives are among the best known and most beautiful of shells. They are found plentifully in all tropical seas, especially in the islands of the Indian and Pacific oceans. They are fond of burrowing in wet sand in quest of bivalves ; and can dart through the water with tolerable rapidity, by expanding and flapping their fleshy foot. They are very rapacious ; and the larger kinds are fished by hooks baited with flesh. The shells are heavy, painted in beautiful patterns and highly polished. The colors are often very variable in the same species ; and as the shape of the shells is generally pretty uniform, there is great difficulty in discriminating several of the kinds. The pillar-lip is not plaited, as in the *Volutes* and *Mitres* ; but there are numerous spiral folds, of which the foremost unite and travel round the base of the spire, forming a band of different color.

In the *Olivellas*, which are all small shells, living in vast shoals on each side of tropical America, the spire is elevated and the mouth expanded at the base. The foot is not so large ; and the typical species have a very small operculum, which is however wanting in *Lamprodoma*. In *Agaronia* the shell is even wider, and very thin. The back is destitute of polish, and is therefore not so much immersed in the foot. It frequents the west coasts of America and Africa, and is found in the Eocene strata. In *Scaphula* the shell is distorted by an enormous lump at the suture.

The *Ancillas* are polished shells, generally of a uniform white, fawn, or brown color, without pattern. They are particularly plentiful in Africa, and in the Eocene strata. In *Dipsaccus* which has, and *Sandella* which has not, a winding umbilicus, the spire is elevated, and the spiral band round the base of the shell ends in a rudimentary tooth. In *Anaulax* the shell is not polished outside, and the shell is thin and wide-mouthed, like *Agaronia* in the last group.

The Harps form a small but well-marked group ; of which the species are so like each other that even the Messrs. Adams did not attempt to subdivide them. They all have ventricose shells, with varicose ribs at regular intervals, which may be sharp or flattened on the same specimen. They are painted brown in beautifully penciled patterns, with shades of pink and white ; and on the pillar is a large callosity, formed by the olive-like foot of the animal. It is said that the creature will part with its tail, rather than be caught ; after the manner of the Italian lizards. In the London Clay is a curious fossil, the "*Buccinum stromboides*" of authors, which forms an interesting transition between the Harps and the *Ancillas*. It has only rudimentary varices ; but their pointed tops remain. The general shape, and the lump on the pillar, formed by the animal's foot, which is too large to enter the shell, show close relations with the true Harps.

The teeth in all the families thus far enumerated are formed on the Whelk type, in rows of three each ; of which the central one is broad and fixed, while the side ones are movable. All three are armed with variously shaped hooks. In the next group of families, the lateral as well as the central teeth are fixed ; and the shell always has folds on the pillar.

*Family FASCIOLARIADÆ. (Tulip-shells and Mitres.)*

This family embraces two very different looking groups of shells, of which *Fasciolaria* and *Mitra* are the types. They agree however in a very peculiar dentition. The central teeth in each row are very small ; but the lateral ones are long, narrow, and armed with points like a saw. The tulip-shells are not very strong, generally knobbed outside, with the breathing canal a little curved. They are known from *Fusus* by a few very slight and slanting folds on the pillar, close to the breathing pipe. The *Fasciolaria gigantea* of the South Carolina seas is sometimes two feet in length, rivaling in size the great *Hemifusi* of the East Indies. Small specimens greatly resemble the *F. princeps* of the west coast, but are at once distinguished by the sculpture on the operculum of the latter. The group called *Fulgur*, which abounds on the Atlantic shores of North America, with the East Indian group *Tudicla*, were formerly reckoned with the *Pyrulas*. Whether they have a whelk-like dentition, or whether they are *Fasciolarias* with undeveloped plaits, cannot be told till their animals have been dissected. Whether it speaks well for the zeal of American naturalists that these large species, which can be so easily examined, should be abundant in collections, as far as the shell is concerned, but as yet undescribed from the living animals, must be for others to determine.

In *Latirus*, the shell is shaped like *Fusus* or *Pisania*, but with a few parallel plaits. In *Peristernia* these evanesce, as in *Fulgur* ; and some species can hardly be known from *Pisania*. In *Leucozonia*, there is a spine in the outer lip, as in *Monoceros*. The stout claw-shaped operculum, which characterizes this tribe as well as the Muri-cids, at once distinguishes the shell : but Lamarck's error has been repeated by many authors, and even by Chénu.

The genus *Fastigiella* is known only by its shell ; which seems to represent the *Cerites* among the *Fasciolarias*. The plaits are obsolete.

The *Mitra* group have always been great favorites. They generally have slender, pointed shells, with elegant sculpture and particularly brilliant painting. There are a great multitude of species, but most of them are rare. They have a love for an insular life ; being found in great abundance in the islands of the Indian and Pacific oceans, while the shores of the neighboring continents have only a few, and those plain species. The Atlantic ocean is not their favorite : even the choice islands of the West Indies only boasting of a few dull species. The pillar lip is always strongly plaited, the top plaits being the strongest. They are remarkable for doubling up their little foot longitudinally, when they draw themselves in. The operculum is generally absent. They have the power of emitting a very nauseous odor when disturbed. Their proboscis is enormously long, out of all

proportion to the size of the animal. It is difficult to say where they find room to deposit it when swallowed. Swainson, who, with many fancies, devoted much time to pointing out the analogies among various groups of mollusks, paid particular attention to the Mitres. It has already been shown that one group passes into the Muricid. Another possesses the dentition of the Volutes. In the restricted group, the *Strigatellas* have the aspect of *Columbella*. They are found under stones at low water, and are generally covered with an epidermis. Even when living, they are often coated over with nullipore, an evidence of their sluggish habits. The *Imbricarias* are, as it were, plaited cones, and *Cylindra* has the shape of the Olives. They live in the sheltered sands of the coral lagoons, and even in the black mud of mangrove swamps. Lastly, the fossil genus *Volvaria* has close relationship with *Marginella*.

*Family TURBINELLIDÆ. ("False Volutes.")*

The Turbinelles are known from the last family by the lateral teeth of the lingual ribbon; which, instead of being saw-shaped, have only one strong horn on each to tear with. The middle tooth, however, is very long and trident-shaped. The shell always has strong, transverse plaits in the middle of the pillar lip. The true *Turbinelli* are pear-shaped, with a long canal. The "shank-shell" is carved by the Cingalese; and when found reversed is considered sacred. The priests make use of it to administer their medicines. The group *Cynodonta*, of which the two finest species inhabit the tropical shores of Atlantic and Pacific America, are compact, and somewhat triangular in form. The shell looks as if it bid defiance to all enemies, being extremely strong and heavy, armed with stout knobs, and closed with a thick twisted operculum. The animal, however, is said to be timid and inactive, shrinking quickly within its shell at the slightest alarm.

In the next section there is only one row of teeth on the lingual ribbon, the lateral series being obsolete. The central teeth have generally three lobes, but sometimes they end in a single spike.

*Family VOLUTIDÆ. (Volutes.)*

The Volutes are large, showy shells; most of them rare, and highly prized by collectors. They have a very short spire, with a mamillated nucleus, which is sometimes disproportionately large. The bottom of the pillar lip is always plaited, with a notch for the breathing pipe, which is short, turned back, and often furnished with little flaps at the base. The foot is generally large, sometimes with a slit on each side near the head, as in the Olives. The tentacles are small, far apart, and joined by a veil. The eyes are on lumps behind the tentacles.

The Boat-shells and Melons are large and thin, with very expanded mouth, and a few sharply-cut pillar-plaits. They are, as it were, Marsupial animals, the eggs being hatched within the mother's body, and the young ones living there till they are more than an inch long. The *Cymbas* are almost exclusively West African shells. They were called *Yet* by Adanson, who tells us that the high winds some-

times drive shoals of them on shore, where they are eaten for food. They have a very large, irregular apex, surrounded by a keeled channel, and a twisted pillar. The *Melos* are brightly painted shells from the East Indies, often with a pretty crown of spines around the short, smooth spire. In *Volutella* (a tropical American shell) the expanded mantle deposits a coat of enamel over the spire, which is often produced into a long horn. *Voluta* (proper) has a small operculum, and numerous secondary plaits. The typical species, from the West Indies, is beautifully painted with a pattern resembling the staves of music. The commoner species belong to the group *Aulica*, in which the shell is generally tuberculated, with a sharp outer lip. In *Scaphella*, a southern form, also found fossil in the English Crag, the shell is narrow and elongated. In *Fulguraria*, the shell is striated, and the foot is comparatively small. In *Callipara*, the shell is like a young cowry, with very small plaits. In *Lyria*, the shell is shaped like *Marginella*, with very small plaits, and ribbed exterior. It is the only form of volute found on the west Coast of America.

The family of the Volutes make their first appearance in the cretaceous epoch, but very sparingly. In the tertiary groups, particularly the Eocene of the London and Paris basins, a peculiar form abounds, called *Volutilites*, in which the spire is sharp, as in *Mitra*, and the plaits are often very faint. A single recent specimen of this group was dredged in 132 fathoms of water, off the Cape of Good Hope, during the voyage of the Samarang.

Another group differ remarkably from the true Volutes in the shape of the central teeth. Instead of having two large lobes on each side of the small central one, they have only one central spike; which rises up so sharply from its arched support, that when arranged over each other on the tooth-ribbon, they present the appearance of a keel. There is no character in the shell by which the *Amoria* can be safely separated from the ordinary Volutes. In the few specimens examined, the surface is polished, and there are five oblique pillar-plaits.

The same lingual detition is found in the little *Volutomitra groenlandica*; remarkable as representing an essentially tropical type on a boreal shore. The animal and shell are shaped for the most part as in *Mitra*, from which the teeth are essentially different: so that it may be either considered the representation of the Volutes among the Mitres; or, as placed by Dr. Gray, the mitred element among the Volutes.

#### *Family* MARGINELLIDÆ.

The *Marginellas* are a numerous group of very pretty little shells, great favorites with collectors from their high polish, and beautiful colors. They are almost all from the tropical seas, and the largest number of finest species are from Africa. If we judge by the shells alone, they form an exact transition from the Volutes to the Cowries; in their plaited pillar and general shape resembling the former, in their glossy coat and thickened lip the latter family. Indeed the transition-genus *Erato* is placed by systematists sometimes in one, sometimes the other group. But so far as the animals are yet known,

they are widely dissimilar. In dentition, they are nearly related to the *Volutes*, having only a central row of teeth. But these, instead of having three lobes, or a spike, are very broad, with nine small serrations. The proboscis is short, I think; the siphon without auricles; and the foot is folded up longitudinally, as in the *Mitres*. They further differ from most of the *Volutes* in their high polish, caused by the sides of the mantle folding over the shell. Sometimes it deposits a large callosity on each side of the mouth.

In the typical *Marginellas*, the spire is distinct; the siphonal notch is not sharply cut out as in the *Volutes*; and there are five distinct plaits on the pillar. They inhabit clear sands, in somewhat shallow water, and glide along with great rapidity. In *Persicula*, the spire is concealed; the pillar has numerous plaits; and the outer lip has an excretory notch, and is generally grooved within. In *Volvarina* the shell is very thin, scarcely thickened at the lip, and with very small plaits on the pillar. Several small species of this group are common in the West Indies. A group of small shells, called *Closia* by Dr. Gray, are extremely like *Cypræovula* in shape. The outer lip is toothed, and the inner has two large and two small plaits.

In the next group of families, the teeth are arranged in rows of seven each; the central an inner lateral teeth being fixed, as in *Fasciolaria*; but the two outer teeth on each side being movable. The inner teeth have numerous serrations on the edges. They are generally very small and transparent; but the animal makes up for their minuteness by having a strong prehensile collar at the end of the trunk. In this are inserted a number of horny plates, armed with numerous rows of conical teeth.

#### *Family* CASSIDÆ. (*Helmet Shells*.)

The true Helmets are large, handsome shells, somewhat triangular in form, with very short spire, narrow mouth, toothed on each side, and the canal suddenly twisted backward. Like the *Murices*, they leave a varix outside the shell at every period of growth; which, in this genus, occurs at every two-thirds of a revolution. The animal has a large strong foot; and the mantle deposits a very thick pillar-lip, the edge of which projects so as partially to conceal the spire. As the shell grows, the twisted canal is covered over by the advancing pillar lip, leaving a cavity behind. The creatures are active and voracious; crawling, with their stout helmet *behind* their heads, (a fashion which ladies have sometimes imitated,) and their nose-pipe bent back over it, along the sandy flats where the unconscious bivalves quietly wait to be eaten. The inner lip consists of various plates of enamel, which lie in alternate colors. Artists have taken advantage of this to carve cameos; which are produced by cutting the figure in one of the layers, and leaving the groundwork in the next. The large cameo-shell, called by Lamarck *Cassis madagascarensis*, is a native of the Bahama Islands, whence large quantities are brought to the Liverpool market. Dead shells have been dredged by Dr. Stimpson off the coast of North Carolina. The colors of the cameos differ according to

the species of the shell. The operculum of *Cassis* is very long and narrow, like that of the *Buccinum* drawn out; but in the swollen helmets (*Bezoardica*) it is shaped like an expanded fan, with the nucleus on the inner margin. The shells of this group seldom make a varix except when mature; and the pillar lip is thin, seldom plaited. In *Levenia* (peculiar to west tropical America) the outer lip is sharp, but thickened within; the operculum being very small, to suit the contracted aperture. In *Cypræcassis*, there is no operculum; the mouth is narrow and toothed on each side like the Cowries; and the inner lip is very thick, but not projecting as in the true helmets. In *Cassidaria*, (a genus almost confined to the Mediterranean,) the shell is like *Bezoardica*, but the canal is only partially bent back: in *Sconsia* it is not bent back at all. In *Omiscia*, the canal is straight, and the inner lip wrinkled: while *Pachybatron* is even more like a Cowry than *Cypræcassis*, having the mouth toothed as in *Trivia* with a notch at each end. The Helmets first appear in the Eocene tertiaries; but their maximum development, as in most other predacious Gasteropods, is in the existing age.

*Family DOLIADÆ. (Tun Shells.)*

The Tuns are nearly related to the Helmets, both in animal and shell. The latter is always very thin and ventricose, with spiral ribs, and a sharply notched aperture. The animal is large, with a very capacious foot, truncated in front, which it swells out with water when swimming. The head is thick, with the eyes on little stalks at the base of the tentacles. The proboscis is stout and long, and armed with a powerful prehensile collar at the end. The breathing canal is turned back, as in the Helmets. In *Dolium*, the mouth of the shell, is very wide and open: in *Malea*, it is curiously contracted, with ribs on each side. The *Malea ringens* is a very characteristic shell of Pacific tropical America. Its fossil remains, discovered by Dr. Newbery on the Atlantic coast, prove that the two oceans have been separated since the creation of the species. The Tuns make their appearance in the Miocene age.

*Family TRITONIDÆ. (Trumpet Conchs.)*

The *Tritons* were naturally associated with the *Murices* by conchologists; the only differences observed in the shells being purely artificial, viz: that in *Murex* the varices (or old mouths) are any number from three to thirteen; while in this family they are two or one and a half. This trifling distinction, however, is found to be coördinate with an essential difference in the dentition; the *Tritons* being in that respect closely related to the Helmets and the *Naticas*. They differ from the previous families in having but a small foot, and a nearly straight siphon, inclosed in the canal of the shell. They are almost confined to tropical seas, and have a much greater love for the old world than the new. All the shells of the family have the outer lip toothed within, and most of them have the pillar lip similarly ornamented. The operculum is generally as in the Muricids.



The large *Triton Tritonis* of the Pacific ocean is a great favorite with the South-Sea islanders, who make a hole near the tip, and then use it as a speaking trumpet. A very similar species (*T. nodiferus*) inhabits the Mediterranean, and has been known to crawl to the confines of the British seas. One of them was kindly given by the ancients to the Sea God, to make his commands better heard: and the poet sings of the old Romans,

“*Buccina jam priscos cogebant ad arma Quirites.*”

The varices appear on every three quarters of a whirl, giving the shell a somewhat distorted appearance. In the subgenus *Gutternum*, the canal is very long and straight, as in *Murex* proper. It is generally of moderate size, and somewhat twisted. In the fusiform species with a long spire, the canal is very short. Sometimes there are no varices till the shell approaches maturity. There is one group (*Argobuccinum*) in which the shell is thin and whelk-shaped, and the varices irregular or absent. It is characteristic of the west coast of America; the *A. nodosum* being found in the tropics, the *A. scabrum* along the foot of the Andes, the *A. cancellatum* in the extreme south, and the very similar *A. oregonense* in the northern districts. These, with a large proportion of the true Tritons, are covered with a very thick, loose, and generally hairy epidermis.

The *Personæ*, or Mask-shells, are Tritons with a broad thin inner lip, and curiously twisted mouth; being to *Triton* what *Malea* is to *Dolium*. The *Euthrice* are regarded by Dr. Gray as Tritons without varix. The shell appears related to *Clavella* or *Peristernia*; but the teeth of the animal have not yet been examined.

The *Ranella* group are very pretty shells, having a row of ornamental varices running up each side of the spire. In the typical species, the operculum is shaped as in *Murex* or *Pisania*. But in *R. crumena* it is formed as in *Pusionella*. This caused Dr. Gray to remove it to the *Cassis* family, supposing that all the shells with round varices had the usual operculum, and all those with sharp-edged ones (*Eupleura*) the abnormal one. Having examined however a number of specimens of the sharp-ridged *Eupleura nitida*, collected by Professor Adams, at Panama, with the opercula in situ, I find that they belong to the Buccinoid type, being oval and annular, with the nucleus near the anterior end of the outer lip. This family appears sparingly, like its congeners, in the Eocene strata. A curious fossil genus, *Spinigera*, from the Inferior Oolite, is intermediate in characters between the spiny-variced *Ranellas* and *Rostellaria*, and may have belonged to either family.

Family CERITHIOPSIDÆ. (*False Cerites.*)

A group of very small shells were separated from the Cerites, by Professor Forbes, on finding that they had a retractile proboscis, and a muricoid operculum. They inhabit all seas which have been properly searched; living in sheltered places near the shore among seaweeds and zoophytes. The largest of them scarcely exceeds an inch in length, and one-eighth in breadth. They are all highly sculptured,

with stout knobs or keels, and are very beautiful objects under the microscope. The teeth of *Cerithiopsis* are said to resemble Triton; but the tentacles are more like those of *Tornatella*. The siphon-pipe is extremely short, not protruding beyond the notch of the shell. In *Triforis*, the whirls turn the wrong way, and the lip of the shell is often twisted into pipes for the reception of the breathing and excurrent ducts. The third pipe behind, which gave the name to the genus, is simply the relic of a former mouth. The shells in each group are sometimes so like each other that they can scarcely be distinguished, except by the direction of the whirls. Yet the animal of *Triforis* is said to belong to the true Cerites.

#### ?? Family CANCELLARIADÆ.

The true position of this family is not yet ascertained. The *Cancellarias* are singularly beautiful shells, always elegantly sculptured, with a few small plaits on the pillar, which are sometimes obsolete. Often the pillar is hollow; and instead of a notch or short canal for the breathing tube, there is only an angular pinch in the shell. The siphon pipe is extremely short; but as to the important characters of the head, the learned differ. Messrs. Adams say that it has neither tongue, teeth, nor proboscis; and Deshayes states that it is a vegetable feeder. Dr. Gray, however, places it near the Muricids. The genus is confined to tropical seas and rather deep water; but an allied form, *Admete*, lives in Greenland, and visits the New England shores. In the boreal group *Trichotropis*, so called from the beautiful hairy fringes on the epidermis; there are no plaits on the pillar. The animal has been described by some authors as having a retractile proboscis; by others as having a muzzle. Whether widely different animals have been grouped together, or whether great mistakes have been made, remains to be seen.

In the foregoing families, when the shell has been partially covered, it has been not by the mantle (as often stated) but by the broad and fleshy foot. In the aberrant family of Fig-shells, however, the foot, though widely extended, is very thin; and the shell is partly enveloped by two flaps of the mantle, as in the Cowries.

#### Family FIGULIDÆ. (*Fig-Shells*.)

The shells of this group are singularly elegant; very thin, pear-shaped, finely cancellated outside, with a long wide canal, which protects the still longer breathing pipe. The animals are beautifully painted, with markings of various colors. They stretch out their long white necks, with flat heads, and large black eyes, and crawl very rapidly over the sands. There are very few species; one inhabiting the Pacific shores of tropical America, another the Atlantic, and the rest the East Indian seas.

We now come to animals having a very different appearance, and furnished with shells having no similarity in shape with those hitherto described. The shells were associated by the conchologists with the

Nerites, with which they really have scarcely even an external affinity. The creatures are very voracious, armed with a retractile proboscis, and furnished with teeth constructed like those of *Cassis* and *Triton*. They have, however, no breathing pipe, the water being conveyed to the gills by a fold in the mantle. The shell consequently has no notch at the pillar, and the operculum (when present) is spiral.

*Family* VELUTINIDÆ.

This is a little group of creatures chiefly from the northern seas, with very thin, slightly spiral shells, ending in large round mouths. The mantle of the animal partly covers the shell, as in *Ficula*. The *Velutinæ* live in deep water in the Eastern Atlantic; *Morvillia* in the West. In *Marsenina* the shell is ear-shaped, (as in *Lamellaria*;) and in *Onchidiopsis* it is simply a horny layer.

*Family* NATICIDÆ.

The *Naticas* are very queer creatures; exceedingly voracious, and yet generally blind; armed with the usual carnivorous appendage of retractile proboscis and horny jaws; and yet, as they walk, looking more like a lump of fleshy sand than a predacious Gasteropod. Their shells are strong, beautifully formed, and very innocent looking; having a short spire, hollow pillar, and round mouth. The operculum is slightly spiral, and is generally horny; but sometimes has a shelly coat outside. The great peculiarity of the animal is its enormous foot, which not only envelops the shell, like a mantle, but is doubled up in front so as to form a wedge-shaped digger, with which it plows up the wet sand. The head is hidden behind the plow, and thus protected from the sand; and as the eyes would be hidden also, they are dispensed with. The two largest species of the group are found, one in New England, the other on the Oregon shores. No sooner does the tide go down than they may be seen plowing just below the surface, in the region where bivalves love to hide, a small portion of the shell just protruding over the moving sand. No sooner do they come in contact with an unhappy *Tellen*, than the plow and the broad foot envelop it, the head stretches out, the trunk is darted out, and the drilling process commences, which ends in the suction of the unfortunate bivalve.

Those who examine the objects on the sea shore in summer time can hardly fail to have noticed some curious sandy, ribbon-shaped, frail substances, curled like a horseshoe. Naturalists have often taken them for zoophytes; and they have been variously described as *Flustra arenosa*, *Eschara lutosa*, *Alcyonium arenosum*, and *Discopora crebrum*. It is however nothing but the nest which Mother *Natica* makes for the protection of her eggs. If held to the light when wet, it will be found to consist of sand, glued together, and filled with little cells arranged in quincunx, each one of which has contained an egg. The *Naticas* are found in all parts of the world, and have existed in all ages, beginning with the palæozoic.

In *Natica* proper, the operculum has a shelly coat, which is often

spirally grooved. The umbilicus (or pierced pillar) is generally spiral, leaving a lump on which the apex of the operculum lies when open. The remaining genera have horny opercula. The northern species mostly belong to the group *Lunatia*, with straight umbilicus and small pillar-lump. In *Neverita*, which is found in subtropical regions, the spire is flattened, the mouth wide, and the umbilicus winds round a lump which more or less fills it up. This lump is sometimes grooved. The shells of *Polinices* have the spire conical, and the umbilicus nearly covered by a very large flattened lump: they are white, or only slightly tinted. *Ampullina*, of which only one species is living, the rest abounding in the Eocene, has a ventricose shell, with the axis not perforated. It is polished by the very large foot, and there is a large lump on the pillar. *Naticella* has a thin, open shell with very small umbilicus, almost covered by a narrow, dark colored deposit. In the form of the shell, it passes into *Sigaretus*, in which the shell is flattened, sometimes ear-shaped, and partially concealed by the animal. The outside, however, is striated, not polished as in ordinary *Naticas*. The operculum is very small, and the animal sluggish and timid. *Naticina* is intermediate between *Naticella* and *Sigaretus*, having an umbilicus but no lump. *Amaura* is a boreal form, with raised spire and solid pillar.

In the families which follow, the teeth are arranged in different and peculiar patterns. The shells are of very dissimilar shapes; but the animals all agree in having a retractile proboscis.

#### *Family* LAMELLARIADÆ.

In this family the foot is enormously large, completely enveloping the shell. There is a slit in the mantle to convey water to the gills. The shell is flat, transparent, or horny. The teeth are in rows of three, as in the Muricids; but the side teeth are very large and trapezoidal. The *Coriocella* is a large black animal, inhabiting the tropical seas. *Lamellaria* and *Ermea* are principally from temperate regions. In *Ermea* there appear to be additional lateral teeth.

#### *Family* SCALARIADÆ. (*Wentle Traps*.)

The Dutch called these shells Winding-Stairs, from the beautiful step-like rings ascending in a spiral. The spire is more or less elevated, with a round mouth and reflexed lip, which leaves a varix at each period of increase. Sometimes the whirls are separated from each other, only adhering by the edge of the rings. This is beautifully seen in the famous *Scalaria pretiosa*, for which the Dutch used to give two hundred dollars, but which may now be bought for one. The animal has a fold in the mantle to convey water to the gills, being the foreshadowing of the siphon-pipe in the canaliculated shells. The foot is extended in front, grooved behind, with a thin, spiral operculum. The head is crescent-shaped, and armed with a strong, fleshy trunk. When disturbed, the creature emits a purple dye. It is very voracious, eagerly devouring putrid meat. The teeth are quite different from those of all other prosobranchiate mollusks, resembling most

those of *Bulla* and *Ianthina*. There are no central hooks. The lateral teeth are very numerous and regular, arranged in lines forming an obtuse angle.

The *Scalarias* are rare, inhabiting deep waters. They are, however, found in all parts of the world, even in the boreal seas. The species are generally very much like one another, and white. The Spaniards at St. Blas wear them as ear-rings, calling them *Caracoles finos*. The shells with irregular varices are called *Cirsotrema*. Sometimes they are almost evanescent; in which case the shell can hardly be distinguished from *Aclis*. Fossil forms, which may or may not belong to this group, are found as early as the oolitic rocks; but true *Scalarias* do not appear till the later cretaceous periods.

The remaining families of this tribe differ from all the previous ones, and indeed from all other known Gasteropods, in having no teeth on the lingual ribbon. In fact the existence of a tongue at all has to be confirmed. They have, however, a retractile proboscis, and probably live by suction. It is said by some careful observers that the *Cancellarias* belong to this section.

#### Family EULIMIDÆ, &c.

The feet in this family are very short behind, but enormously produced in front; and are used not merely for crawling, but for exploring in advance. The tentacles are slender, with small eyes immersed in their base. *Eulima* has a pointed shell, with flat, glossy whorls, and is generally white. The mouth is like *Melania*, with a very thin spiral operculum. *Leiostraca* is very slender and elongated, with periodic thickenings every half whirl. *Niso* is umbilicated, and often highly painted. Many of the *Eulimæ* have the axis twisted, especially near the apex. This is very much the case in the group *Stylifer*, the animals of which live as parasites immersed in star-fish, or on the spines of sea-urchins. They do not appear to have an operculum. The *Entoconcha* has been found living in *Synapta digitata*.

#### Family PYRAMIDELLIDÆ.

These creatures differ from the *Eulimas* in having the tentacles short, broad, and folded together. The foot is not prolonged in front. The operculum has few whorls, and is very thin, generally wrinkled. There is a rudimentary breathing fold in the mantle. All the animals of this family are born with a reversed spire; but no sooner do they commence their independent life than they twist themselves round, and continue their growth in the usual right-handed manner. The reversed nuclear shell is generally found at the tip of the apex, more or less immersed in the first regular whirl, and giving the spire a somewhat truncated appearance: in some species it even projects beyond the sides of the spire. In the typical group, *Pyramidella*, the shell is sculptured with transverse ribs, and the pillar is armed with strong plaits. The mouth is pinched up in the region of the rudimentary breathing hole. The operculum is narrow and notched, to suit the long contracted aperture. In *Obeliscus*, the shell is smooth

outside, and the lip periodically thickened within. The plaits are very strong, often projecting beyond the mouth. Sometimes there is only one stout fold. In *Odostomia*, the sinistral apex is very small, the shell Rissoa-shaped, with one tooth on the columella, which sometimes (as in *Auriculina*) becomes obsolete. In *Monoptygma*, the fold is slanting.\* In *Chrysoallida*, the shell is strongly sculptured, and the shell contracted at each end. The outer lip in the adult is extremely thin in front, but thickened behind. The species are very numerous on the west coast of America, where they are found in the crevices of dead shells. All these creatures are very minute. The *Chemnitzias* are somewhat larger, a few species actually reaching an inch in length. They are very much turreted shells, with large sinistral apex and melanoid mouth, without plait. Most of the species have flattened whirls with transverse plaits; but in *Eulimella* and *Menestho*, they are smooth. In *Aclis*, the whirls are tumid; and the mouth is sometimes round, like a *Scalaria* without rings.

Large shells are found in the palæozoic and oolitic rocks, which are referred provisionally to this family; but the characteristic apex can seldom be examined, and their true position is doubtful. In the tertiary strata, we find representatives of most of the living forms.

Very few species in this family abound in individuals, and from their minuteness and rarity they are seldom seen in collections: but very few families boast of so many specific forms. They are more numerous even than *Rissoas*, both in the British seas and in the Gulf of California. Shell sand, especially from deep water, should always be carefully searched for them; and the sinistral apex carefully examined, to distinguish them from *Rissoids*, &c.

#### *Family SOLARIADÆ. (Perspective Shells.)*

The shells grouped together in the *Trochus* family by Lamarck, are found to belong to five very widely separated groups. The true *Trochus* is a Scutibranch, allied to the Ear-shells and Limpets. The *Trochita* is a Rostriferous Pectinibranch, allied to the Slipper-limpets. The *Risella* belongs to the Periwinkles, in the typical portion of the same group. The *Phorus*, or Carrier-trochus, belongs to the further extreme of the same group, being a scrambler, allied to the Strombs. While the *Perspective Top-shells* are found to possess a retractile proboscis, and to have many points of resemblance with the very differently shaped *Pyramidellids*. The shell of *Solarium* is known by the wide open umbilicus, which has always a crenulated keel within, ending in a notch at the base of the mouth. The shell is top-shaped, with a flat base, and is always beautifully sculptured. The point of the spire is rather flattened, and there may always be noticed a minute hole, even in perfect specimens. This is caused by the nucleus of the shell, which is reversed and globular as in the *Pyramidellids*, being turned upside

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\*This genus was constituted from very different shells. The supposed original type is an abnormal *Ancillaria*. The name is here kept, as by Woodward, for shining, sculptured East Indian shells, intermediate in form between *Odostomia* and *Tornatella*. As the animal has not yet been observed, their true position is uncertain.

down, and inserted, bottom upwards, in the succeeding whirl. The animal has a large foot, with flat, paucispiral operculum, and short tentacles folded sideways. In *Torinia*, the base is rounded, and the operculum is very singular, being *conical*, with many whirls. *Bifrontia* is, as it were, a *Torinia* rolled out flat. Sometimes the whirls scarcely touch. The mouth is square, as in *Solarium*. The genus was constituted from French fossils; but Mr. McAndrew has found it living in very deep water, near Teneriffe, with an operculum and sinistral apex exactly like *Torinia*. The genus *Philippia* consists of smooth *Torinice*, with flat operculum. It is said by Philippi to have an animal like *Trochus*; but this is probably a mistake, as the apex is sinistral. *Discohelix* is smooth and flat like *Planorbis*: it is doubtful whether its relations are with *Bifrontia* or with *Vitrinella*. It is found fossil in the American Eocene strata, and living in the Mediterranean.

A large number of fossil genera are referred to this family by Chénu, but their true place is doubtful. Many Trochids have a large crenulated umbilicus, and the characteristic reversed apex can scarcely be observed in the older fossils.

Three families, differing from each other very much in the shape of their shells, but still having many points in common to distinguish them from the ordinary siphon-bearing univalves, have been separated from the rest of the predacious Gasteropods by Dr. Gray, under the name

#### TOXIFERA.

They have a retractile proboscis: but instead of a separate lingual ribbon, the tube of the trunk is turned in upon itself, and armed with two rows of long barbed teeth, implanted singly in the skin of the fleshy tube. The teeth are curiously formed, resembling the sting of a bee when seen in the microscope; and probably have more vitality than those of the ordinary type. In some species, the end of the tube is large enough to admit the little finger; and the creature is able to inflict a decided bite.

#### *Family* CONIDÆ. (*Cones.*)

The Cone-shells are great favorites with collectors, in consequence of their brilliant painting and regular patterns. The *Conus gloria-maris* has more than once sold for \$250. Almost all the species, however, are formed on one plan; and in the living state, the colors are hidden by a skin, which is often very rough and thick. The animal has a short, strong foot, square in front, and with a large hole underneath, through which water is sponged up. It bears a long narrow operculum, of concentric layers beginning from the point: but if it is mended after fracture, the nucleus is in the centre, as in other tribes. The siphon-pipe is long, extended through the notch of the shell. There is always a notch at the other end of the mouth also. The head has two long slender tentacles, with the eyes along their sides. When the proboscis is drawn in, it leaves a funnel-shaped expansion, or veil, in front of the head. This veil is fringed at the end in *Tuliparia*; and

probably also in *Rollus geographicus*, which differs from the rest in having no operculum. The Cones are found in all tropical seas; but abound most in the Indian Ocean and Eastern Archipelago. Some of the species are very widely distributed, reaching from the Red Sea to Easter Island and the Gallapagos. They prowl in the holes and fissures of rocks, and the winding passages of coral reefs; where they crawl slowly in depths ranging from low-water mark to forty fathoms. The shells are generally heavy: and as the animal grows stouter, he absorbs the inner whirls of the shell, leaving only a very thin partition. At the same time he preserves his weight by depositing thick coats in the region of the spire. Shells therefore which a "collector" would throw away, may be valuable to grind down and show the inner structure.

The *Dibaphus* is a puzzling shell, intermediate between *Conus*, *Mitra*, and *Terebellum*. Its true position cannot be stated without a knowledge of the animal. Fossil Cones first appear in the chalk: and are tolerably common in the tertiary strata. The *Conorbis* of the London Clay is lozenge-shaped, closely approaching in form some members of the next family.

#### Family PLEUROTOMIDÆ.

In this family the head is truncate, without a funnel. The shells are generally turritid, and are only known from *Fusus* by a slit in the outer lip, near the suture, corresponding with a slit in the mantle of the animal. The typical genus, *Pleurotoma*, has a long canal, and the slit separated from the suture. The operculum is flat, somewhat triangular, with the nucleus near the canal. *Drillia* differs in having a short canal. These forms are peculiar to tropical regions. They are represented in Northern seas by *Bela*, which has a somewhat similar operculum; but the slit is nearly obsolete, and the pillar is flattened. *Lachesis* has a Mamilated spire, and a Buccinoid shape.

Another group is characterized by the nucleus of the operculum being in the centre of the long side, as in *Pusionella* and *Bezoardica*. In *Clavatula*, the canal is short; the shell resembling *Drillia*. In *Tomella*, the spire is short and the canal produced; the shell resembling a *Clavella*, with a wave near the middle of the outer lip. There is a thick deposit near the suture, as in that genus.

A third group has no operculum at all. The *Clathurellæ*, (*Defrancia* of Millet; the true *Defrancia* being a Polyzoon,) are among the most beautiful of small shells. They are like a *Drillia*, with a deep posterior notch close to the suture; and the whirls are swollen and delicately cancellated. They are found in temperate as well as in tropical climates. In *Mangelia*, the notch is very slight, and the shell plain; being in fact a *Bela* without an operculum. The *Citharæ* are a group of beautiful little shells, like flattened Harps. They have regular transverse ribs, notched at the suture: the mouth is narrow and straight, toothed or wrinkled within, like *Oniscia*. Dr. Gray places them with *Cassis*, their true position being of course uncertain till the animal has been examined. In *Daphnella* the shell is thin and ventricose, very finely sculptured, and with the family notch almost obsolete. The shell is closely related to *Metula*, which has probably a Muricoid animal.



The known species in this family amount to at least five hundred. First appearing in the later cretaceous age, they very rapidly became plentiful in the tertiary strata, three hundred species having been already described. But although so plentiful in forms, they are generally, like the *Pyramidellidæ*, rare in individuals; and collections may often be seen entirely destitute of them. They are generally found in deep water, ranging however from low water to a hundred fathoms; and culminate in the China seas and in west tropical America.

*Family TEREBRIDÆ. (Augur-shells.)*

The Augur-shells form an aberrant family, in general easily recognized by the very slender and produced spire, with flattened whirls and a deeply-notched aperture. Although several of the species are tolerably large, and very common in the Pacific islands, their anatomy is as yet but little known. This group, like the other Toxifers, has only appeared late in the history of our planet. About thirty species have been found in the tertiaries; but in the existing seas, fully two hundred species have been discovered. They live in deep water, almost always in tropical climates. So far as known, the teeth and proboscis are like those of other Toxifers, but the foot and head of the animal are very small. The tentacles are close to the mouth, exceedingly minute, and with mere specks of eyes at their summits. Sometimes the eyes and even the tentacles are not to be seen; and the head is little more than a mouth, as in the shell-bearing Pteropods. The nose-pipe however is very long, and reflected through the sharp notch. The intro-mittent organ is longer still, like a living thread proceeding from the nape of the neck. There is a small, horny operculum, not filling the mouth, and shaped somewhat as in *Pleurotoma*. The shells are generally glossy, heavy, and prettily painted and sculptured. The upper whirls of the shell are often of chalcedonic texture, the inner cavity having been filled up with glossy shelly matter. In this respect there is a striking contrast between the Augurs and the Screws, which latter group partition off the upper whirls with thin septa. The Screw-shells therefore are often found broken; while the Augurs are generally perfect. The Augurs are so slender that sometimes as many as thirty whirls may be counted on a shell three inches long but not a quarter of an inch across at the broadest part. It can hardly be believed that the creature can balance his heavy pole, crawling like an ordinary Gasteropod, and supporting his weight on so short a foot at an enormous leverage against him. It is not improbable that he lives in the midst of sandy mud, through which he can easily push his needle and twist round; leaving the top of his long nose in the water. In such an abode, eyes would be of no service.

It is not yet known how far the differences in the shells are coördinate with those in the animals. Dr. Gray divides the family into those with, and those without tentacles and eyes. From the former he separates a genus *Leiodomus*, in which the suture is callous, like *Bullia*; but the foot is small, not bulky, as in that group. For the present, it is convenient to separate the non-sculptured species as *Subula*; keeping *Terebra* for those with a band near the suture. The

beautiful group *Myurella* has the band nodulous. *Euryta* is a curious group in which the spire is shorter, and the canal so twisted that the pillar appears pierced. The form of these shells offers a transition to *Buccinum*; while a few other species present the aspect of *Cerithium*.

We have now passed under review all the Gasteropods which are known to possess a retractile proboscis. It is not certain that all of these are strictly carnivorous; and it is almost certain that some tribes which have a permanently elongated muzzle are not vegetarians. Between these two great leading divisions of the comb-gilled crawlers, there is a somewhat anomalous group, the true position of which is not yet ascertained. It is strange, (and not, perhaps, very creditable to naturalists and collectors,) that Cowries have been among the commonest shells from the earliest times; abound not only in species, but in individuals; form a regular staple of trade; are found in all warm seas; and yet a reliable account of the anatomy of the animal is still a desideratum. Scientific observers have frequently given accounts of them, and the creatures are figured in many of the great voyages; and yet Dr. Gray asserts that it has a short muzzle, grouping it with the land and sea Periwinkles, while the whole army of ordinary naturalists declare that it has the retractile proboscis of the Whelks. At my request, Dr. Stimpson examined the animal of the large and typical *Cypræa testudinaria*, which had been brought home by the United States Exploring Expedition; and to our surprise it did not accord with either the one or the other type, but, on the contrary, furnished us with an example of a *retractile muzzle*. The snout, contracted in alcohol, was about half the length of the shell. Instead of being drawn in from the base, as in Whelks, it was drawn in from the tip; The tongue-ribbon was coiled up in a cavity near the stomach. Probably the end of the muzzle protruding in front of the tentacles has been mistaken for the ordinary rostrum.

The teeth of *Cypræa helvola* are very like those of the land and sea Periwinkles; but those of *Trivia europæa* have no small resemblance to those of *Natica*. The teeth of *Ovulum* are altogether peculiar; whether, therefore, the egg shells are rightly classed with the Cowries, remains to be seen.

#### Family CYPRÆIDÆ. (Cowries.)

The Cowry shells, when adult, are nearly globular, not showing any spire, with a narrow mouth, toothed on each side, nearly in the middle of the base; with a deep notch at each end. They are almost always smooth and polished. When young, however, they present a very different shape; being then very thin, with an open mouth, sharp lip, and short spire. At that period they have the general aspect of Olives without the plaits; and, as they never display the same shape or pattern that they do in mature life, they have sometimes been described as different species. The adolescent Cowry curls-round the sharp edge of his mouth, and then begins to make teeth on each of the lips. At the same time, the mantle spreads out, forming two great flaps, one of which envelops each side of the shell, and deposits layer over layer of

enamel, till the proper pattern has been given. A line is generally seen on the back of the shell, where the two flaps met. The Cowries are very pretty animals, with the mantle-lobes generally adorned with fringes or ornamental painting. The breathing pipe is very short, and often fringed also. They have long, slender tentacles, with eyes midway up. The foot is very large, but can be withdrawn, with the mantle lobes, into the shell. The Cowries are shy, and crawl slowly. They hide themselves in coral reefs and under crevices of rocks. They are found in all tropical regions, but there are very few on the American coasts. The difference in this respect between the Pacific shores of America and the Pacific Islands, is very remarkable. On the east coast of South America no species has yet been found.

The Cowries form no inconsiderable an item in trade; the larger species being brought to port in great numbers, for sale as ornaments; while one of the smaller species, *Cypræa moneta*, is collected (as gold) for money. It passes current in Africa, as the medium of exchange. Many tons are annually brought over from the East Indies and the Pacific Islands, to transport again to the negroes of the Senegambian region. In 1848, sixty tons were brought into Liverpool alone. Cowries were found by Dr. Layard in the ruins of Nimroud. The typical species have a singular excavation near the notch under the pillar lip.

In the pear-shaped Cowries, *Luponia*, this part is irregularly plaited. In *Aricia*, the base is flattened by thick masses of shell, which project over the sides.

In the *Trivia* group, the foot is short in front, but greatly lengthened behind: the breathing canal is long also. The shell is ribbed or covered with pustules; the ribs are carried round the lips, instead of separate teeth; and the pillar is scarcely excavated. All the very small Cowries belong to this group. *Cypræovula* is intermediate in form between this and the next family; while *Erato* has a shell shaped like *Marginella*, with minutely crenulated lips and polished back. The Cowries first appear in the later cretaceous beds, and are now at the maximum of development.

#### *Family* OVULIDÆ. (*Egg and Shuttle Shells.*)

As far as the shells are concerned, the *Ovula* may be described as unpainted Cowries without teeth on the pillar lip. The animal also is sufficiently like the Cowry, in general appearance. The teeth however in the only species examined (*Ovulum ovum*) are so unlike that or any other known type, that their habits have probably some great peculiarity to correspond. On each side of the short central tooth, is a tall hooked lateral with jagged edges; and on each side of that, a very large fan-shaped tooth, bordered by a deeply-cut, curly fringe. In *Ovulum*, the outer lip is turned in and toothed: in *Calpurnus*, the shell is hunch-backed, with a curious wart at each end. In *Carinea* there is a ridge across the back, and the lip is not toothed.

But the most singular shell belonging to this group is the *Weaver's Shuttle*, (*Radius volva*), in which each end of the lip is produced into a very slender canal, longer than the body of the shell itself. The

creature folds its foot round the *Gorgonias* on which it lives, carrying its shuttle gracefully over its head, the edges of the lip and canal being elegantly adorned with tufts. In other species the canals become shorter and shorter till they are only a prolonged notch. The smaller forms are colored differently, in the same species, according to the coral on which they feed. In *Simnia*, the outer lip is quite sharp, and the animal has a long foot and breathing pipe, as in *Trivia*. None of the Cowry or Shuttle tribe have any operculum.

#### SUB-ORDER ROSTRIFERA. (*Muzzle Bearers.*)

The remainder of the Comb-gilled Crawlers have a longer or shorter snout which is not retractile, and is technically called a *rostrum*. In the Strombs and their allies, the snout is very long, and the teeth are adapted for tearing carrion, on which they live; but in most of the families, they browse upon the herbage. The proboscis-bearing shells are all from the seas or estuaries; but the vegetarian tribes are also found in fresh waters or on land. In the latter case, the gill cavity is changed into a lung. The teeth of the Rostrifers are always in seven series, 3·1·3: but in the first group the lateral teeth are claw shaped, as in *Cassis* and *Natica*: while in the Periwinkle group they simply have serrated edges, adapted for rasping plants. The Rostrifers are arranged by Dr. Gray according (1) to the shape of the foot, (2) to the position of the eyes, and (3) the shape of the gills. The dentition has not been regarded by him of primary importance, as in the trunk-bearers. It is impossible to group them in a straight line so as to show all their known affinities; a few families, as the Strombs, Wormshells and Apple-snails, appearing to disturb every natural order of succession.

#### FIRST GROUP. *Teeth arranged as for animal food.*

##### *Family STROMBIDÆ. (Wing Shells.)*

The Strombs and their allies are very strange creatures. They are rather leapers than crawlers, and jump about the shore, using their foot as a leaping pole, searching for dead fish and other refuse, of which they are the useful scavengers. The shape of their body is altered to suit their change of habits. As they stretch themselves out of the shell, the body seems made up of scraggy limbs, like a dead tree partially deprived of its branches. The foot, which is a stout, muscular lever, is the trunk of the tree: from this branches off the head, if indeed you can say that there is any distinct head or neck; for it consists, first of a stout truncated branch, which is the long muzzle with the mouth at the end; next of two smaller branches, also truncated at the end; these appear to be tentacles, but are really stout pillars for the eyes to rest in; lastly, of the true tentacles, which are little pointed twigs growing out of the eye-stalks. The second great branch is an arm going off at right angles to carry the operculum. This is long, claw-shaped, and toothed at the edge, only attached to the animal by

a small scar. It serves therefore as a shield when the animal is in motion, as well as a door when it is at rest.

The eyes in the Strombs are remarkably well formed, being (like those of the Cephalopods) more highly organized than in many fishes. They have a distinct crystalline lens, with an iris differently colored in different species.

The shell also is very peculiar. When young, it resembles a cone, with the spire more or less elevated, and a very thin lip. But as it approaches maturity, it spreads out a great wing, which is gradually thickened with layer upon layer from the mantle, till the shell is very strong and heavy, and able to tumble over without injury, as the animal scrambles on the rocky shore. The pillar has a twisted canal for the breathing pipe; and near it is a very deep notch in the outer lip, where the animal can save his head from a blow as the shell falls over. The wing is further notched at the suture.

The *Strombus gigas*, or "Fountain-shell" of the West Indies, fills up the earlier whirls with solid matter, and sometimes weighs five pounds. It is a favorite ornament in consequence of the delicate pink color of the mouth; and is used for cameo-cutting like the Helmets. It is alas! ground to powder wholesale, for the manufacture of the finer kinds of porcelain; three hundred thousand having been imported into Liverpool in one year, from the Bahama islands.

The Scorpion-shells (*Pteroceras*) are like the Strombs when young: but when mature, they develop six or more long claws, variously twisted. In *Rostellaria*, the head-notch is close to the breathing canal, and the spire is long. An excurrent canal generally ascends the spire, and is sometimes long enough to twist over at the apex and come down on the other side. In the aberrant group *Terebellum*, of which only one species is now living, the shell is glossy, sharply truncated at the base, without canal or notch, and with a sharp outer lip. The operculum is very singular, having the appearance of a bird's foot with claws. The creature, when taken from the water, will leap several inches. In one of the Eocene species, the spire is rolled in and hidden; in another, a canal ascends the spire as in the Spindle-Strombs.

The fossil forms belonging either to this group or to *Aporrhais* appear first in the Oolites. Nature might seem to have amused herself in the strange and varied shapes which many of them assume, especially in the *Spindle* and *Scorpion* tribes. The true Strombs however barely appear in the tertiary age; at present they culminate, while the other forms are dying out.

#### *Family PHORIDÆ. (Carrier Top Shells.)*

Very different in the form of shell, but agreeing in the peculiar shape of the animal, are the Carrier Shells. They live on banks of stones and dead shells, chiefly in the East Indies, over which they scramble, stretching out their foot-pole, with the opercular arm and the long muzzle, like the Strombs. Their eyes however are very inferior, and are placed at the bottom of slender tentacles. They have no breathing tube, the shell being top-shaped. Contrary to the habit of

the Strombs, they all make their shells with a wide rim ; but they have the propensity to stick pieces of stone and broken shell to their backs, so as often to hide what they have made themselves. By this means they probably escape detection. In *Phorus*, the pillar is solid, and the operculum thin, concentric, with the nucleus at the side. In *Onustus*, the pillar is open, and the layers of the triangular operculum are piled one upon another.

*Family* APORRHAIÐÆ. (*Spout Shells*.)

These creatures may be regarded as Spindle-strombs, passing back to the ordinary type, with the common eyes and crawling foot. The wing of the shell is always enormously dilated, and often clawed ; but no mark has yet been found out by which the numerous fossils of the secondary rocks can be referred to one or to the other group. The two British species, *A. pes-pelicani* and *A. pes-carbonis* have, as their name implies, very wide claws. The New England species has a broad palm without fingers. The breathing canal in all the members of this family is simply a fold in the mantle entirely covered by the shell. The operculum is like that of the Whelks, but the animal is widely different. The *Struthiolaria* have a simple varix instead of a wide lip. They are peculiar to the Australian seas. A very curious shell, *Halia*, like a marine *Achatina*, has been referred to this group ; as also has *Trichotropis* ; but we must wait for a knowledge of their anatomy.

*Family* PEDICULARIADÆ.

The *Pedicularia* is a curious little shell, living as a parasite on coral in the Mediterranean. When young it is spiral, when adult flat and open like *Concholepas*. The most singular point about it is the dentition, which is like that of *Strombus* and *Aporrhais* exaggerated. The outside teeth are produced into enormous claws, like the fingers of a bat's wing folded together. In this respect it resembles *Carinaria*. This and the following families are of sedentary habits, either crawling about in crypts and chinks, or remaining absolutely fixed for life. They are very degraded animals, as compared with the noble Strombs ; yet their dentition is more allied to them than to the Periwinkles. The fixed shells must of course live on what the water vouchsafes to bring them ; why therefore their tongues should be armed with weapons of war it is difficult to say, as the bivalves, which live in the same way, are entirely destitute of them. How much our ignorance is revealed to us by the little knowledge which we possess !

*Family* CALYPTRÆIDÆ.

The Slipper-limpets and their allies have the gills in long, slender plates, forming an oblique line across the cavity. They may be described as Carrier Shells, which have become tired of a jumping life, and have gone into retirement. In shape of shell, *Trochita* has a very close resemblance to *Phorus*. But instead of a leaping foot, retractile into the shell, and closed with operculum, its foot occupies the base of the "top ;" and the operculum is the rock or shell to which it adheres.

In *Galerus*, we have simply a spiral plate running round inside a conical shell. In the "cup and saucer limpets," (*Crucibulum*), the conical shell has a cup-like process within, more or less attached to the side of the saucer. In *Crepidula*, the cone is flattened into a boat, and the cup into a deck, producing the "Slipper-limpet." In all these forms, which (though differing in the types) are closely connected by intermediate shapes, the animal presents the same appearance. There is a small flat foot, and a little head, with eyes on slender tentacles, and a short muzzle with lips. The mantle scarcely extends to the edge of the shell. The tongue is armed with teeth, as ferocious as those of *Natica* and *Cassis*, and yet they seldom walk about, adapting themselves to the shape of the object to which they adhere, and growing very finely under circumstances in which locomotion is impossible. Indeed, in the genus *Calyptrea*, in which the "cup" is cut across, the animal exudes a shelly support from its foot, by which it is absolutely cemented to the rock. The remarkable changes of form which these creatures assume according to the circumstances of their growth, were detailed in the Smithsonian report for 1859, pp. 197-205. In their early stage however they are very similar; having a regular, spiral, globular shell, from the pillar of which the deck or cup is afterwards developed.

#### Family CAPULIDÆ. (*Bonnet Limpets*.)

The animals in this family closely resemble the Slipper-limpets, but the adductor muscle is not fixed to any shelly support in the form of cup or deck. The shell is simply an irregular cone, twisted more or less into a spiral at the apex. Some of the living species of *Capulus* greatly resemble the *Velutinas* in form; but they are heavier shells. The *Amalthea* eats a deep hole into the shells on which it rests, with a horseshoe ridge in the centre. *Hipponyx* deposits so thick a shelly layer under its foot (like *Calyptrea*) that the fossil species were long thought to be bivalve shells. The horseshoe muscular scar, formed by the attachment of the adductor, is very conspicuous in this family. It equally exists however in the spiral shells.

Even in the Palæozoic rocks appear forms which cannot be distinguished from the members of this family. They have been described as *Metoptoma*, *Platyceras*, *Acroculia*, &c.

#### Family NARICIDÆ.

The *Naricæ* are a group of shells, looking like cancellated *Natica*, but made by a very different animal. They are, as it were, Bonnet-limpets rolled into a true spiral shell. Their habits are sluggish, but they move about somewhat, and are provided with a very thin, sub-spiral operculum. As in the last families, the creatures are ovoviviparous, keeping their eggs under a fold in the mantle till they are ready to hatch. The shells were first called *Vanicoro* by the French naturalists, but it is scarcely fair to call a race of creatures by the proper name of a place. It is probable that the curious shells called *Neritopsis*, with a scooped out pillar lip, belong to this family. Only one species is now living, but many are found fossil in the newer rocks. Without a

knowledge of the animal, however, it is impossible to say whether its relationships are not rather with *Nerita*, or even with *Natica*. The teeth in this family are not properly known.

*Family AMPULLARIADÆ. (Apple-Snails.)*

The Apple-Snails form a very natural and peculiar group, standing by themselves, and only presenting an external similarity to the other fresh-water shells with which they are generally associated. They inhabit the marshes of the tropical regions, both in the Old World and the New, and are particularly fine and plentiful in Africa and South America. They have a large globular shell, in some fossil species so like *Natica* that it is hard to distinguish them. In general the shell is thin, with a strong glossy skin and a horny operculum of concentric elements. Although there is no notch in the shell, the creature has almost always a long breathing pipe, like that of the Whelks; but with this difference, that it is slit along the upper not the under side.

The Apple-snails are truly amphibious, having, as it were, a gill in the corner of a lung. This arrangement is necessary to enable them to survive the long summer droughts, when they bury themselves deep in the mud and wait for better times. They have been known to live many years out of the water. Their eyes are of respectable dimensions, planted on little pillars like the Strombs, with a pair of very long, slender tentacles in front. There appears to be a second pair of shorter tentacles in front of these, but they are really the two halves of the muzzle which is split and lengthened out. The teeth are formed on the tearing type of *Natica*, &c. The creatures are eaten in vast numbers by marsh birds, who, if they cannot get at their prey through the operculum, carry them up to the branch of a tree and break the shell by the fall.

In the true *Ampullarias*, which are peculiar to tropical America, and are called "Idol-shells" by the Indians, the pipe is long and the operculum horny. The group *Pomella* have thick, heavy shells, with very wide mouth. In *Marisa*, which is found in the East Indies as well as in America, the shell is flattened down till it resembles a *Planorbis*. *Lanistes*, from the African rivers, has a flattened, reversed shell. In *Meladomus*, also an African form, the spire is turreted, looking like a reversed *Paludina*. In *Pachystoma*, which includes most of the old-world Apple-snails, the breathing pipe is short, and there is a thickened ledge round the mouth, to support a somewhat shelly operculum. In *Asolene*, which frequents the marshes of the La Plata, there is no breathing pipe visible. The estuary species are often found mixed with marine shells, both on existing shores and in the tertiary beds.

SECOND GROUP. *Teeth arranged as for vegetable food.*

Among the land snails, there are some very beautiful tribes, almost confined to the tropics and the warmer temperate regions, which cannot be properly reckoned with the true pulmonate Gasteropods. Instead of a real lung, they have (so to speak) a gill-cavity formed for air-breathing, left open by the mantle which is free from the nape of



the neck. Any one who will compare a living *Cyclostoma* with a Snail or a Periwinkle, (or their pictures,) will observe how unlike the general shape of the body is to its air-breathing ally, and how similar it is to the Sea-snail. The general resemblance is fully borne out by the details. The *Cyclostoma* has the eyes at the base of the tentacles, a long snout, a spiral operculum, and teeth arranged in seven series, 3·1·3, after the rasping fashion of the true herbivorous Rostrifers. Moreover, the sexes are distinct, exhibiting a far higher type of structure than in the hermaphrodite snails.

The *Cyclostoma* family are known, among land shells, by their graceful shape, varying however from that of a *Planorbis* to a *Turritella*, the whirls often scarcely touching, and ending in a round mouth. They are very numerous, both in sectional forms and in species. Dr. Gray divides them into thirty genera, principally on differences in the form of the operculum and mouth. The following are the principal groups.

*Cyclostoma* proper has a shelly, ovate operculum, of few whirls as in *Litorina*. *Tropidophora* has the whirls somewhat flattened and keeled. *Otopoma* has a ear-shaped excrescence partially covering the umbilicus. In *Tudora* (a West Indian group) the mouth is pinched at the top. *Chondropoma* has the operculum nearly horny. *Choanopoma* is a singularly beautiful group, abounding in Jamaica, with a spreading, generally frilled, lip, and a raised operculum. *Realia* is a small *Litorina*-shaped group from the islands of the Old World and the Pacific, with thin horny operculum; and *Bourciera* is a singular shell from Ecuador, shaped like *Helicina*. In this group the sole of the foot is grooved, and the animal progresses on each side alternately.

In the *Cyclophorus* group, the shell is depressed, the epidermis thick, and the operculum horny and many-whirled. The tentacles are long and pointed, and the foot broad, without groove. In *Aulopoma*, the operculum has a grooved border, fitting over the lip of the shell. *Leptopoma* has the lip not complete, as in the snails. *Diplomatina* is pupiform; and *Alycæus* has the last whirl curiously distorted. So the fossil form *Ferrussina* has the mouth leaving the regular spiral, and turning upside down.

In *Craspedopoma*, the operculum has two rims, one of which fits within, the other outside the contracted mouth. *Cyclotus* has a flattened shell; and the operculum has a shelly layer outside the horny one. In *Pterocyclus*, the operculum is turreted, as in *Torinia*; and the lip is produced into a roof-shaped beak at the suture. The form is found in the East Indian Archipelago; as also *Opisthoporus*, in which a little tube comes out behind, as in *Typhis*. *Megaloma* has a cylindrical shell and horny operculum; and *Cataulus* has the base keeled round the pillar, with a horny, many-whirled operculum, which can be drawn down out like a cork-screw.

The *Pupinæ* are a group of beautiful little glossy shells from the East Indian Archipelago. The lip is notched, in front and at the suture; and the operculum is thin, horny, and many-whirled. In *Pupinella*, there is a rudimentary canal, twisted back. *Rhegostoma* has the axis bent, as in *Streptaxis*; and in *Callia* there is a shining deposit over the spire, as in the *Marginellæ*.

*Family* HELICINIDÆ.

This group consists of very pretty compact little shells, which most abundant in tropical America, but are also found in the Pacific and East Indian islands. They have half-oval mouths, with an operculum of concentric elements. The teeth are 3·1·3, as in *Litorina*. The animal has a propensity to eat away the inner layers of its shell, like *Nerita*. *Helicina* has a plain mouth, with a lump on the pillar lip. In the West Indian group *Alcadia*, there is a slit on the basal lip, and the shelly operculum has a projecting tooth, to correspond with it. In *Trochatella*, the shell is top-shaped, and there is no lump on the pillar. In *Lucidella*, the lip is distorted with teeth. *Stoastoma* has a twisted notch, reflected as in *Pupinella*.

*Family* ACICULIDÆ.

A family of very small, turreted shells connects the land with the sea Periwinkles. They have the eyes on the back of the head, behind the Periwinkles, and a very thin operculum, with few whirls. *Acicula* has the outer lip of the shell plain; in *Geomelania* it is produced into a tongue.

*Family* TRUNCATELLIDÆ. (*Looping Snails.*)

These little creatures have a very short, round foot, and a muzzle prolonged into two lappets. They loop on these, like the geometric caterpillars. They have highly organized eyes, behind the tentacles. A peculiarity in *Truncatella* is that on reaching maturity it drops off its long, slender spire, fastening up the broken part. A little Rissoid shell, called *Tonichia*, is said to have similar peculiarities.

*Family* JEFFREYSIADÆ.

Among the vast group of tiny shore shells commonly called *Rissoa*, Mr. Alder found some, small among the small, who never draw their eyes outside their houses. They are placed far back behind the tentacles, and look through the transparent shells, which float among seaweeds in rocky pools. In *Jeffreysia*, the muzzle is cleft into false tentacles, as in *Ampullaria*. In *Hyla*, it is plain, and the creature has relations with *Pyramidellids*. The operculum in *Jeffreysia* is of concentric elements, with a bolt standing from it inside at right angles.

*Family* RISSOIDÆ.

Almost on every coast where there are any stones for sea-weed to grow from, there will be found, living among the algæ, or dead in multitudes among the sand, a great many species of shells like very tiny Periwinkles, but much prettier in their shape, sculpture, and coloring. They generally have a short, slightly cleft muzzle, joined on to the front of the foot, which is pointed behind. There is a curious little tail under the operculum. The lateral teeth are more claw-

shaped than is usual in the rasping tribes, and furnished with very minute serrations.

Already several differences have been pointed out among the animals of this tribe, which may or may not be confirmed. Some of the groups may hereafter be removed to other families. The principal genera are as follows: The true *Rissoæ* are somewhat pupiform in shape, with a thickened lip, slightly pinched at the pillar, and a thin, slightly-spiral operculum. In *Cingula*, the mouth is sharp and melanoid, with flattened whirls. *Alvania* has the whirls round and is generally sculptured; the mouth also is round, with thickened lip. In *Rissoina*, which pretty much takes the place of *Rissoa* in tropical climates, the shell is generally ridged, and the mouth thickened, produced in front, with a strong pinch at the pillar: the operculum has a tooth at the side, as in *Nerita*. *Barleia* has the shape of *Rissoa*, with an annular operculum armed with an internal stump. *Skenea* is flat like a *Planorbis*, with a round mouth and many-whirled operculum. Some forms go to the opposite extreme, and are shaped like *Turritella*. They have been supposed till lately to belong to *Aclis*. The shells of this group may always be known from the *Pyramidellids* by the point of the spire being regular, not reversed. The *Hydrobias* live in brackish water, in immense multitudes. The *Nematuras*, which float under dead leaves in the rivers of the East, are like *Hydrobia* with a curiously contracted aperture. The relations of *Ammicola* have not yet been clearly made out, though the creatures swarm in the fresh waters of North America. In shape they are intermediate between *Bithinia* and *Valvata*; but are known from both by the operculum, which is spiral, with few whirls.

#### *Family* LITORINIDÆ. (*Periwinkles*.)

The Periwinkles are formed for sea-shore life, and are destined to scrape off and consume the various kinds of marine vegetation. They abound everywhere except on sandy beaches, and each species has its appropriate level in relation to the tide. Some are found at extreme low water; some at the ordinary high tide; some where only the spring tides reach them; and a few where they are never covered with water except in storms. Some crawl up the mangroves on the shore, and some have been found walking on trees half a mile from the sea. The ordinary Periwinkles have one very large gill in numerous plates lying across the inner surface of the mantle. They have horny jaws, and a thin spiral operculum, generally of few whirls. In shape some of the shells resemble *Turbos*, and some *Trochuses*: but they may always be distinguished by their want of pearly lustre. The *Litorina litoria* is a favorite article of food with poor people in English cities; but the *L. rudis*, which inhabits a higher zone and brings forth its young with a hard formed shell, is left to enjoy its native rocks. The tongue is two inches long; and the creature walks first on one side of the foot, then on the other. There is a fold in the mantle presenting an approach to the breathing pipe of the Whelks. There are some river species, of Naticoid shape, which live on stones below water in the Danube and La Plata. They are called *Lithoglyphus*. The

Australian Periwinkles are top-shaped and ash-colored: they were first named *Risella*. Some species, living in marshes of brackish water both in England and the East Indies, instead of having the eyes on the base of the tentacles, as in all others of the tribe, have them on the tips; or rather perhaps on eye stalks joined to the tentacles. They are called *Assimineæ*. In *Tectarius*, the shell is top-shaped, strong, and rudely knobbed outside. *Echinella* is intermediate between this form and the true Periwinkles; with knobbed exterior, often a lump on the pillar, and a many-whirled operculum. *Modulus* has also a many-whirled operculum: it is flatly top-shaped, with a deeply-cut tooth at the pillar. *Fossarus* differs from the Periwinkles in having little frontal lobes between the tentacles. The habits of the animal, as well as the shell, greatly resemble *Narica*. A few species from the west coast of America have a lump on the pillar, and are called *Isapis*. Shells closely allied to Periwinkles have been found in the Oolitic rocks. In the newer tertiaries, the present species are found, even with color bands; and with shells curiously distorted (as now in the Baltic) from the too large admixture of fresh water.

#### Family LACUNIDÆ.

This little tribe of northern shells differs from the Periwinkles, (which the shells greatly resemble, except that they have a chink in the pillar,) in having no jaws. Dr. Gray even assigns to them a proboscis. There are two little tails behind the operculum as in *Rissoa*. The *Lacuna vincta* is common in the New England seas, and deserves a careful dissection. There is no siphonal fold in the mantle.

#### Family PLANAXIDÆ.

The shell of *Planaxis* differs from *Litorina* in having a sharp notch in the pillar, through which protrudes a small breathing pipe. The creatures are all tropical, and are extremely plentiful where they live. One little species is remarkable as being common both to the West Indies and the Red Sea. They have a solid, stumpy foot, and a long snout. In *Quoyia*, there is a curious sharp keel running along the pillar. The shells of this family are often remarkable for the great difference in appearance between the young and the adult state. This is peculiarly the case in the little Rissoid shells called *Alaba*, of which two extremely similar species are found in tropical America, one in each ocean. They would scarcely be distinguished when adult; but the sculpture of the nuclear snout at once separates them. The operculum is half-mooned shaped and slightly spiral.

#### Family LITIOPIDÆ. (*Gulf-weed Snails*.)

The *Litiopæ* are tiny shells, very like *Planaxis*, but the animals have a curious series of lappets on each side of the mantle, as in the Top-shells. They travel over the ocean on the gulf-weed, from which they suspend themselves by spinning glutinous threads. If they lose their hold, they make a bubble which they send up to find the weed

again, having first anchored themselves to it by a thread. The operculum is said to have many whirls.

*Family VALVATIDÆ.*

Another aberrant family consists of little shells looking like fresh-water *Cyclostomas*. They have perfectly round mouths, and the shell is sometimes a little raised, sometimes quite flat. Alone of all the Prosobranchiate Gasteropods, their gills are exposed to view; being exerted, on the left side of the animal when walking, in the shape of a very slender pinnate leaf. When the animal retires, the gill is drawn into its cavity. The operculum is many-whirled. The *Valvatæ* live in rivers, lakes, and ditches in temperate regions of both the Old and New World. As the *V. tricarinata* is extremely common in the northern States, it is to be hoped that some naturalist will examine whether the creature is hermaphrodite, as stated by Dr. Gray. If so, this again is an anomaly in the Comb-gilled order. Shells not to be distinguished generically from living *Valvatas* are found even in oolitic strata, associated with *Bithinæ*, *Paludinæ*, &c. It would appear that the types of Molluscan life have not changed in fresh waters so much as in the marine forms.

*Family PALUDINIDÆ. (River Snails.)*

The *Paludinæ* take the place of the *Ampullariæ* in the temperate regions; but the animal is much more like the Periwinkles. They have a long, contractile muzzle; and neck-lappets, folded to make a rudimentary breathing gutter. The eyes are on stumps at the base of the tentacles. The *Paludinæ* are viviparous, the young being born with a delicate shell of three whirls. The operculum is thin, and annular as in *Ampullariæ*. The tongue-ribbon is strong but slender; the teeth not much bent, and very finely hooked. The creatures are very sluggish, generally living imbedded in soft mud at the bottom of rivers or deep ditches. They live on decaying animal and vegetable matter. The smaller species are oviparous, and have a shelly coat to the operculum. They are called *Bithinia*, and have only one neck lappet on the mantle. Among the mountain streams of Ceylon, sometimes at a height of six thousand feet, are found a group of shells remarkable among fresh-water snails for their solidity. Their surface is generally rough with knobs or ribs, and the point eroded by the acid of the water. The last whirl is very spacious, as in the *Ampullariæ*, and is closed by an operculum increasing concentrically from the margin, presenting a shape very similar to that of *Purpura*. They have been erroneously described as *Paludomus*, and are now known under the name of *Tanalia*.

*Family MELANIADÆ.*

The *Melantias* are a tribe of fresh-water snails, abundant in all the sub-tropical regions of the globe. In America they swarm in all the southern regions, to the great delight of species-makers, who can at any time immortalize themselves by wading in some unsearched stream;

and to the corresponding confusion of those who have to work-up their achievements. They can even subsist in the severe winters of New York, but shiver at the thoughts of Lower Canada and New England. The Mediterranean appears to have limited their migration into Europe to a very few aberrant species in the extreme south. In the East Indies and Pacific islands, they again appear with something of the prolific character which culminates in the United States. They are known from the *Paludinas* by the edge of the mantle being fringed; they have no neck-lappets, but there is generally a rudimentary siphonal fold. The muzzle is large and dilated; the tongue long and slender; the gills in a series of stiff, cylindrical plates. The operculum is almost always sub-spiral, resembling *Planaxis*. The shells present considerable extremes of form; and, if marine, might be easily referred to *Mesalia*, *Fusus*, *Bullia*, *Planaxis*, *Litorina*, and *Drillia*. Yet the gradations between these extremes are so slight, and the differences in the animals of such little importance, that the separation into natural groups is a matter of great difficulty. The shells are seldom attractive, being generally covered with a dull skin, and often with adhesive mud; many of them however are elegantly sculptured, and a few have very graceful forms. It is much to be regretted that American collectors, who have not been slow to avail themselves of the exuberant riches lying at their feet, which are so acceptable to European naturalists, have so generally entirely neglected the preservation and study of the opercula; and that so many points in the physiology and habits of these easily-observed animals have not yet been made known.

The shells of *Melania* proper have a turreted spire; oval mouth, with sharp, straight lip. Like the *Paludinas*, they delight in the muddy parts of rivers, but do not despise stony places. Many of the species are said to be viviparous. In the section *Melanella*, the spire is shortened; and in *Melacantha*, there is a coronet of sharp spines. These are mostly found in the Old World and the Pacific islands. In *Melanatria*, which includes the finest East Indian forms, and many fossils of the European tertiaries, the shell is strongly sculptured; the outer lip is waved; and the operculum has several whirls, with a central nucleus. *Pachycheilus*, which includes many American forms, has a similar operculum, with a smooth shell, and a thickened pillar-lip. The stumpy, ridged *Ceriphasia* of the American rivers, and the stout, nodulous *Vibex* of West Africa, agree in having the outer lip very much waved, leaving a broad channel before and behind. *Gyrotoma*, a North American form, has a lump at the back of the pillar, and a deep, narrow slit at the suture. Very common in the whole district west of the Alleghanies are the stumpy little *Leptoxes* (of Rafinesque; \* *Anculotus* of Say); which are like fresh-water Periwinkles in their habits. Having no tide-waves to dash them, they establish themselves on stones in the rapid places of rivers in such numbers that

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\*The description is so inaccurate that Philippi in his Manual assigns it a place among the Lymneids. The name of Say was in common use till the conchological archaeologists revived the prior but deservedly forgotten name of Rafinesque. Changes of currency, however necessary to introduce the benefits of a decimal coinage, are not necessarily useful to science, merely because a bad coin was made before a good one, which has got into general acceptance.

often you cannot tread without crushing them. They live a sedentary life, adhering pretty firmly to the surface by their short, strong foot. The spiral part of the operculum is often worn away. They are represented in the Himalayan regions by *Paludomus*; which, with the fringed mantle of *Melania*, has the annular operculum of *Paludina*. In the West Indian islands and the tropical districts of South America are found a group of shells differing from the typical *Melantias* in having the pillar sharply notched; they are called *Hemisinus*. The genus *Melanopsis*, which is peculiar to the old world, being found from Spain to New Zealand, consists of stumpy shells notched for the siphonal fold, and furnished with a lump at the suture like *Bullia* and *Polinices*. The elongated forms, found in Africa and the tropical East Indian islands, are called *Pirena*, and have the lip very much produced in front. The shell of *Clionella* has a distinct notch in the outer lip like *Drillia*. It inhabits the African rivers, but the animal has not yet been examined. Lastly, in the Southern States of America are found the beautiful shells of *Io*, in which there is not merely a notch, but a distinct, straight canal, to convey water to the gill cavity.

*Family CERITHIADÆ. (Cerites.)*

The Cerites are a very numerous tribe of turreted shells, with a notch or canal at the bottom of the pillar, in consequence of which they were classed with the *Muricids* by Lamarck. The animals however closely resemble the Periwinkles, *Melantias*, &c. They are known from the latter by the absence of fringe on the mantle, by their strongly sculptured shells, and by the greater development of the siphonal fold in the mantle. This is never produced into a projecting recurved pipe, as in the notched Proboscidifers. The Cerites are found in all parts of the world; but the typical species do not ascend higher than the Mediterranean. Some of the species emit a bright green fluid when disturbed. Like their neighbors the Periwinkles, they are extremely plentiful in individuals. They inhabit the ebb-tide line and deeper waters round shores, and certain groups are very plentiful in brackish water and salt marshes. The shells of *Cerithium* have a very short, slightly bent canal, and an operculum like *Litorina*, of few whirls. *Rhinoclavis* has the canal bent back like *Cassidaria*, with a fold on the pillar, and a porcellanous texture in the shell. The fossil group *Nerinea*, found in the older secondary rocks, is like an exaggerated *Rhinoclavis*, with a large number of plaits, both on the pillar and inside the whirls. The shell is often very slender like *Terebra*, which it may have resembled in habits. One species of *Rhinoclavis* has been figured by Adams with a muricoid operculum, but other species are known to possess the paucispiral form. In the remaining members of the family, the operculum is round, with many whirls. The dwarf Cerites of the northern seas have only a slight pillar notch, and bear some resemblance to the elongated *Rissoas*; they are called *Bitium*.

The fresh water *Potamides* are known by their brown epidermis, and lip produced in front. The fossil forms are very numerous and beautiful in the tertiary strata. In *Pyræus* the outer lip is arched

and twisted over the canal, making it somewhat tubular. *Lampania* has a shell shaped like *Pirena*. *Terebralia* has a broad pyramidal shell with flattened whirls. The mouth is square, with a deeply waved outer lip, and a plait on the twisted pillar. The *T. telescopium* is so plentiful near Calcutta as to be burnt for lime. In the very pretty group *Cerithidea*, the notch is almost obsolete; the mouth is round; and on reaching maturity it is reflected back. The shells are very thin and light, and very commonly decollated at the point. The animals live in mangrove swamps, estuaries, and salt marshes. They crawl so much out of the water that they have been taken for land shells; and in the dry season, they hang themselves from the mangroves by glutinous threads.

It is not known whether the animals of *Triforis* are most related to *Cerithium* or *Cerithiopsis*. Perhaps among the lefthanded species which have been grouped together under that name, there may be found some of each kind. (See *Cerithiopsida*, above, page 185.) The ancient *Cerites* are of the *Nerinea* form: the typical race does not appear till the cretaceous age, but rapidly develop in the tertiaries.

#### Family TURRITELLIDÆ. (Screw-Shells.)

The *Screws* are to the vegetarian section of Comb-gilled Crawlers, what the *Augers* are to the boring tribe. The shell is very long, and regularly pointed; the whirls very numerous and generally rounded; and the texture for the most part strong, and somewhat porcellanous. The creatures do not drop away the pointed end, like *Cerithidea* and *Truncatella*; but they are fond of marking off the left portions, one after another, by plain partitions. In external appearance the Screw-mollusks are extremely like the *Melania*s and *Cerites*. They have a very short foot, squared in front; and a short, thick muzzle, somewhat united to the foot below. The mantle is fringed even more prettily than in *Melania*. The operculum is round, with many whirls, as in *Potamis*; often with a thin fringe at the edge. As the foot is grooved below, the creature has the power of moving right and left alternately. But the heavy, long spire and short foot betokens in general a sluggish habit; and the Screws generally repose in stiff mud like the Augurs, in rather deep water. But while the blind Augurs grub *in* the mud for their prey, the Screws expose their delicate fringe and long thin tentacles with eyes on stumps beneath to search for their food above the surface. The teeth are broad and extremely finely serrulated, like those of *Paludina*; the tongue-ribbon being very small. There is a rudimentary breathing fold, but the pillar is not notched. The gill-comb is extremely long.

The animals have not been examined in a sufficiently large number of species to ascertain whether there are any generic differences among them. They have been thus separated provisionally, according to the shell. *Turritella* has the mouth round. In *Haustator*, it is somewhat squared by the shouldering of the base: very fine species of this group are found in west tropical America. In *Torcula*, the middle of each whirl is curiously hollowed out. The shells of *Mesalia* are short, with flat-



tened whirls, oblong mouths, and waved outer lip. They are like strong marine *Melantias*, and are found in Greenland, Africa, and the Eocene tertiaries. *Eglisia* has a deeply-marked suture, small mouth, and thickened pillar. Shells apparently belonging to this family are found in very old rocks. The typical forms begin in the neocomian strata, and are exceedingly abundant in the tertiaries. Among the latter is the genus *Proto*, in which there is a broad notch near the front of the pillar. The shells of *Scoliostoma*, which range from the Devonian to the Trias, form a remarkable transition to the Vermetids, the aperture being produced and trumpet-shaped.

It is difficult to say what are the true relations of the

#### *Family CÆCIDÆ,*

whose tiny shells, like bent tusks, closed at one end, are seldom seen in the cabinets of collectors, but present many points of singular interest to the inquirer. The *Cæcum* is first born as a flat spiral shell, like *Skenea* with which indeed the animal has not a few relations. But after making two or three turns, it suddenly leaves the spire, and grows outwards in a very slightly arched curve. In this state it remains permanently in *Strebloceras*, the earliest Cæcids known, from the London Clay; like a shepherd's crook, twisted at one end into a spiral. But in the living genera, it soon drops off the spire, plugging up the broken end; and as it advances in growth, it brings the plug forward, and drops off the part behind, always living in a part about the same length, broader in proportion as it approaches maturity. In *Cæcum* proper, the shell advances in the same plane; so that if all the décollated parts had been preserved, the whole would have had somewhat the shape of a *Spirula*. In the West Indian genus *Meioceras*: however, where the shell has to keep pace with the growth of the sponge among which it lives, the coil is in loose cork-screw, like a drawn-out *Turritella*. The animal agrees with *Turritella* in having a short foot and many-whirled operculum: also in partitioning off its forsaken portions. But the division, instead of being a homogeneous septum, continually repeated, as in the Screws, is a very curiously-shaped plug, the form of which is constant in each species. The teeth, instead of being broad, with fine serrations, as in the Screws, are said to be pointed and hooked, as in the carrion-feeders. As they are principally found in worm-eaten passages of dead shells, they may be employed as scavengers, to scrape up the decaying matter that might otherwise corrupt the water. The adult shell has both its mouth and plug slanting, so that it may be able to crawl through a very narrow hole. In the earlier stages, the shells of all the *Cæca* are smooth and slender; but as they attain maturity, the group *Anellum* develops concentric rings, the *Elephantulum* longitudinal furrows; while the shells of *Fartulum* are smooth, and look like tiny sausages. In *Brochina*, the plug is spherical, and the operculum swelling outwards. The Cæcids culminate in tropical America, east and west; and are curiously rare in the Pacific ocean.

*Family VERMETIDÆ. (Worm-Shells.)*

On almost all shells and stones that have lain long in the sea are to be found irregularly twisted shells, sometimes assuming a more or less spiral form, sometimes almost straight. A large proportion of these have no connection with shell-fish: being true worms, the sea analogues of the earthy tribes; jointed animals with red blood and symmetrical organs. When taken alive, these are recognized by the beautiful bunch of feelers, bearing an operculum (sometimes adorned with stag's horn processes, and never spiral) on a fleshy cup in the middle. Some of these, as the tiny *Spirorbis*, so prolific on sea weeds, stones, &c., in the colder seas, have pretty regularly formed spiral shells. But in the tropical and warmer temperate regions, many species are found, the animal of which is not indeed so beautiful, but far more highly organized. It is indeed a true mollusk, and may be considered a degraded *Turritella*, adapted to a fixed life; just as *Magilus* is a degraded *Purpura*.

In *Vermetus* proper, the shell begins exactly like a ridged *Turritella*. The animal is of course then free, and will probably be found to have its foot somewhat developed. But after a season, tiring of its too great exertions, it lies down in a safe place, attaches itself to the mooring, and continues its shell in an irregular twist. The foot then becomes obsolete, or rather serves the purpose of a support for the operculum. The head has short tentacles with little eyes; and a small muzzle, often cleft into false tentacles, as in *Ampullaria*, *Rissoella*, and the *Slipper Limpets*. The teeth have not yet been examined. The gill is very long and slender; and the mantle edge is sometimes fringed.

The shells of *Siphonium*, though spiral at birth, have no *Turritelloid* portion. The operculum is thin and concave, with very few whirls: in *Aletes*, it is many-whirled, as in the Screw-shells, but small in proportion. In *Bivonia*, the operculum is shaped like a "wide-awake" hat, so as to be drawn very tightly into the shell: the outside is terraced, and often encrusted. In *Petalocochnus*, the operculum is very thin, and the middle whirls of the loose spire very curiously cut up by thin spiral laminae, reminding one of *Nerinea*, or of a drawn out Calyptraeid. These two last groups are often twisted together in large masses, stretching out straight tubes at the end to get the best access to the currents. The shell of *Spiroglyphus* is partly imbedded in the living shells to which it adheres, growing in the form of *Spirorbis*. In *Serpulorbis* and *Cladopoda*, there is no operculum, the foot of the latter being produced like a club. The shells of *Siliquaria* have either a slit or a necklace of holes, running along the whole outer edge of the irregular spire; corresponding with a slit in the mantle to admit water to the long gills. The operculum is terraced as in *Torinia*. The animal is said to be hermaphrodite; another mark of inferior development connecting this with the next order.

The shells of this family cannot be certainly distinguished from those of sea worms; but can in general be recognized by their compact porcellanous texture, glossy within, like an unrolled *Turritella*: while the worms are generally of dead hue, and earthenware consistency.

We have now completed our sketch of the Comb-gilled Crawlers; the largest, and (except the Cuttles) the most highly organized group of mollusks. In the next order, the gills consist of two series of plates, more like those of the bivalves. This comparatively trifling distinction is found to be coördinate with an inferior type of development in other points of structure. The animals, while often much more ornamented than in the former order, are not as it were so concentrated. There is never found a breathing pipe or a predacious snout. The teeth, instead of being compacted into rows of 3·1·3, each one of which has its special shape, are spread out into very complex series of glassy hooks, of which many in the same line are the dittos of each other. The shells, while many of them are of surpassing beauty, nacreous as the pearl oyster, often lose their spiral form, adopting that of the simple cone. And the arrangements for the continuance of the species, instead of being separated on different animals, are united in the same individual, which is supposed to be capable of self-impregnation.

ORDER SCUTIBRANCHIATA. (*Shield-gilled Crawlers.*)

Family NERITIDÆ. (*Nerites.*)

Almost all the Scutibranchs are shore shells, living wherever there are rocks or marine vegetation. Some are found at slight depths; a few of the lower kinds only being found in deep water.

The Nerites are almost exclusively confined to tropical shores. They grub among the stones and rocks on the sea-weed, sleeping by day, and prowling about, harmless as they are, towards night. They are plain-looking creatures, like the Periwinkles, from which they are at once distinguished by the great length of their tentacles, and the eyes which rise on short stumps behind. The shells are very readily distinguished by the broad flat pillar-lip and stumpy spire. Though greatly abounding in species and in individuals, there are very few generic forms among them. The true *Neritas* are strong, sea shells, with stout teeth or wrinkles on the pillar lip. The operculum is sub-spiral and shelly, with a stout knob fitting like a hinge under the pillar lip. The *Neritinas* are much thinner shells, almost exclusively inhabiting fresh waters, where they adhere to stones or water plants. The pillar lip is thin and smooth, or only very finely toothed; the operculum also is thin, with a horny edge. In the group *Clithon*, the whirls have a row of spines pointed towards the apex. These live on stony bottoms, in still, tropical waters. Some of the *Neritinas*, especially in the group *Neripteron*, with winged pillar lip, have very short spires; they then pass into the fossil form *Velates*, which is peculiar to the French tertiaries. Here, while the mouth of the shell has the usual Neritoid appearance, the back is conical, with only a minute spire at the point. In *Pileolus*, a form peculiar to the oolitic rocks, there is no spire at all, the back of the shell being exactly like a limpet. Another oolitic form, *Neritoma*, has a notch in the outer lip, like *Pleurotomaria*. A large group of fresh-water Nerites in the East Indian Archipelago are limpet shaped, but with the point at the side,

resembling a fresh-water *Crepidula* with an operculum. These are the *Navicellas*, the operculum being small, and imbedded in the foot. *Pelex* is a little New Zealand shell, brought home by the United States Exploring Expedition, in which the apex is on one side.

All the Nerites have the power of absorbing the inner whirls of the shell, which makes the transition from the spiral to the straight forms less extraordinary. The teeth are arranged in very complicated patterns, the inner rows being of many different shapes, flanked by numerous rows of hooks at the sides.

The great bulk of the Scutibranchs consist of the Top-shells, forming the staple of Linnæus' two genera *Trochus* and *Turbo*. The animals are all formed on the same type; and are known by the beautiful fringe and feelers round the foot and head, the long tentacles and eyes behind on stumps, and the long and very complicated tongue-ribbon. Although the animals can be easily obtained and examined, being very generally found between tide-marks, the beauty of the shells has generally engrossed the attention of collectors; and we are left in ignorance how far the observed differences in these are coördinate with distinctions in the living creatures. The divisions, both into families and genera, are therefore for the most part artificial; but are rendered necessary in consequence of the great multitude of species. They are found in all seas, from the tropics to the frozen ocean. When their beautifully sculptured and delicately painted shells are found in company with the dull Periwinkles, and their highly ornamented bodies are compared with the plain forms of the latter, it is difficult to realize the fact of their greatly inferior organization.

#### *Family TURBINIDÆ.*

The shells of this group are all tropical, or nearly so. They reach the Mediterranean, but not the British or temperate American seas. They are distinguished by a very thick shelly operculum of few whirls. The under layer of the shell is brilliantly pearly.

The *Turbo* group have rounded whirls and a circular mouth. The large species are imported in great quantities to be polished for ornaments; the hemispherical opercula used formerly to be regarded as a charm for sore eyes. The typical species have a smooth, or slightly granular operculum. In *T. sarmaticus*, the surface is made up of large granules. The Snake-shell group, which abound in the Pacific islands, have a very rough outside, and a chink at the pillar. The shells of *Marmorostoma* are flattened, with a deep umbilicus, and a groove round the operculum which has more whirls than usual. *Ninella* is broad and thin, with a wide, channeled umbilicus; the operculum is nearly flat, with ridges like the human ear. The shells of *Callopora* are like the typical forms; but the opercula are deeply grooved, with beautiful granular ridges. They are peculiar to west tropical America. To the south of *Callopora*, on the west of South America, is found *Prisogaster*, with the shape and dull aspect of *Litorina*, but a shelly, sharp-edged operculum of few whirls. The New Zealand form *Modelia* has the general shape of *Ziziphinus*, (a species of which is unfortunately figured in this place in Chénu's Manual, f.

2551.) but it has a stony operculum, with two grooves outside. The pretty little African group *Collonia*, have small Trochoid shells, and a many-whirled shelly operculum with a central pit. Species belonging to this type are found in the Paris Eocene beds. Fossils of Turbinoid form, which may or may not belong to this family, are found in all ages from the earliest times.

Another group, typified by *Imperator*, has the shell top-shaped. The whirls and base are flat; the operculum thinner and oblong. The shell is always roughly sculptured, and often considerably incrustated. The large *Pomaulax* of Lower California has a channeled base, and an operculum with three bent ridges. *Uvanilla* has a similar base, with two ridges on the operculum. The New Zealand *Cookia* has one ridge, and a shell shaped like *Modelia*. The shells of *Astraliium* have a very flattened spire, with a sharp keel round the base armed with spiny scales. An aberrant form of this is the Japanese *Guilfordia*, which has a brilliant, golden nacreous texture; and a few long spines.

#### Family PHASIANELLIDÆ. (*Pheasant-Snails.*)

The shells of this group differ from the *Turbos* in being porcellanous, but not nacreous. The shelly operculum is smooth outside. The shells are always smooth, and very brilliantly painted. They have much the shape of Periwinkles, and the animal has a very long snout. Small species are found in most warm seas, but their favorite haunt is Australia. This part of the world retains the oldest fauna now living, and has many points of similarity with that of the oolitic rocks. The prevalence of large *Phasianellas* in the European oolites and present Australian seas is a striking case of similarity.

#### Family TROCHIDÆ. (*Top-Shells.*)

The animals of this family are very beautifully fringed, and the shells generally highly painted. Very few excel them in the elegance of the sculpture, and the beautiful shapes of their pearly mouths. The shells are generally thinner than the *Turbos*, from which they may always be known by the thin, horny, glossy operculum of many whirls. The genera into which the old genus *Trochus* have been lately divided, cannot be regarded as established until the peculiarities in teeth, fringes, opercula, &c., have been examined in a much larger number of species. The following are the principal groups: The typical species are conical, with many whirls, the last of which often bulges, with the pillar-lip twisted and concave in front. In *Cardinalia*, the surface is sculptured, the last whirl a little narrowed-in, with the pillar-lip ending in a point in front. The small conical shells with a flat pillar and square mouth, which for number and beauty might be considered the principal of the groups, have been called *Ziziphinus*, from the commonest European species; but as great confusion arises from raising specific names to the generic peerage, it would be far better to revive Swainson's name *Calliostoma*. In *Pyramidea*, the whirls are very angular and narrow, and the pillar is sharply twisted so as to approach *Terebralia* among the Cerites. *Polydonta* has the bottom

of the pillar scooped out, and the lip ornamented with blunt teeth. When these become obsolete, with sharply keeled whirls, the shell resembles *Trochita* among the Slipper-limpets, and is called *Infundibulum*.

The Australian and New Zealand Top-shells present some curiously drawn-out forms; in which the nacre has generally a greenish hue. The shell of *Cantharis* has a plain pillar, like *Phasianella*. In *Elenchus*, which is polished and painted like the Pheasant-snails, there is a tooth on the pillar; and in *Thalotia* the mouth is toothed round. *Bankivia* is a curious *Eulima*-shaped shell, with the pillar bent and truncated. Although it is so common as to be used for ornaments by the natives, its operculum and animal are still unknown.

In the next group the shape of the shell is more ovate, with flattened spire and rounded base. *Livona* has convex whirls and a round mouth, with a deeply-pierced pillar and lump bordering the hole. The *L. pica* is one of the most characteristic shells of the West Indies: a closely allied form was taken alive by Colonel Jewett in California. The operculum has fewer whirls than is usual in the tribe. *Trochiscus*, a form peculiar to California, is nearly allied, but has the operculum with raised and scaly edges. In *Gibbula*, a very common European form, the whirls are shouldered, and the pillar-lip is plain. *Margarita* is a closely allied boreal group, with very thin shells and round mouth. The very similar forms *Oxysteles* and *Diloma* are like a *Livona* with a closed pillar.

The shells of *Clanculus* are remarkable for their ringent mouths, twisted by numerous teeth. *Monodonta* is shaped like a Periwinkle, with one stout tooth on the pillar, and others round. *Euchelus* differs from it in being umbilicated, with but few whirls in the operculum. *Osilinus* is like *Monodonta*, with only one plain knob on the pillar. *Omphalius*, the shells of which replace *Gibbula* on the west coast of America, is like a plain *Clanculus*, with the pillar lip toothed, somewhat as in *Modulus*. *Tegula*, which is peculiar to the Panama region, has the mouth of *Osilinus*, with the Trochoid shape of *Omphalius*.

*Monilea* is a little group of sculptured shells, resembling *Torinia*, in which the open pillar is bounded by an ornamented spiral ridge.

The *Delphinula* group are in shape like strong, shaggy sea *Cyclostomas*. The pillar is quite open; the whirls scarcely touch; and the mouth is round.

Several fossil forms appear allied to this and other recent genera; but in ignorance of their opercula, we cannot locate them with certainty. *Euomphalus* is like a flat, thin, unsculptured *Delphinula*, with angular mouth. The typical species of *Cirrus* are so irregular that they might be considered *Vermetids*. The *C. nodosus* of the English Oolites, sometimes begins as a left-handed *Turritella*, ending in a flat *Euomphalus*; and sometimes take a reversed top-shape from the beginning. In some species, the whirls are disunited. Some species of *Euomphalus* are believed to have had a stony operculum like *Turbo*.

#### Family LIOTIDÆ.

Some of the shells classed with *Delphinula* are found to have the

horny operculum ornamented outside with spiral dottings of shelly matter. The mouth always ends in a round varix. They are separated under the name *Liotia*.

There is a group of very beautiful little white shells, with flattened spire and large mouth, the relations of which are not yet properly ascertained. As far as the shells are concerned, they pass both into *Liotia* and *Rotella* by insensible gradations. The shells are not pearly as in the Trochids. The species are very numerous in west tropical America, and probably in other warm seas, but have hitherto escaped observation. They are here provisionally classed with *Rotella* simply from the relations of the shell.

#### Family ROTELLIDÆ.

The shell of *Rotella* is like a marine *Helicina*, flattened, with a large lump on the pillar. It is glossy, but not pearly. The operculum is horny and many-whirled. The animal is said to have a retractile proboscis. At any rate it offers the anomaly of having only one of the eyes properly developed. One of the tentacles is curiously transformed into a long veil, which has been mistaken for a breathing pipe. The creature is said to grub in sand, like the *Naticas*. The shells are beautifully painted, with such variety of pattern that it is hard to find two alike. Several allied forms are found in the secondary rocks. *Chrysostoma* takes the form of the Periwinkles, with a very small lump. *Camitia* is toothed, like a polished *Clanculus*. *Isanda* has an open pillar, with a toothed mouth. *Teinostoma* is like a *Rotella*, with the mouth drawn away from the pillar, and often ending in a pinch. *Ethalia* is intermediate between the three last forms; having an open pillar nearly covered by the revolving lump of the inner lip. In *Vitri-nella* there is no lump; the pillar is extremely wide and open; and the outer lip is often waved. The shells are all minute; and are remarkable for the large size of the nucleus and the beauty of the sculpture. *Cyclostrema* is like a large *Vitri-nella*, with a round mouth; it is said to have a shelly operculum. Lastly, *Adeorbis* has a very open mouth, with the outer lip doubly waved. In form, this group passes into the next family.

#### Family STOMATIDÆ.

These may be described as Ear-shells without any holes. The animals are like those of *Haliotis*, but without the mantle-slit. Like them the mantle is fringed, but there are no feelers round, as in the Trochids. They pass into the former family though the genus *Stomatella*, in which the shell is shaped like *Sigaretus*, and the animal can be drawn into it. There is a small, horny operculum of few whirls. The shells in the whole family are brilliantly pearly; they are small, and almost confined to the East Indian islands. In *Stomatia*, and the remaining genera of the family, there is no operculum, and the animal cannot withdraw its large foot into its shell. Sometimes, when frightened or angry, it throws off the back of the foot, like the Harps. In *Microtis*, which has a flat, spiral shell exactly like an unbored *Haliotis*, the foot is cleft in front below the head. In *Gena*, the shell is drawn out, and

the spire very small. Just as we found conical forms among the Nerites, so we have a conical Trochid. It is called *Broderipia*, and looks just like a small, pearly Limpet.

*Family PROSERPINIDÆ.*

A curious little family of land shells are believed by Dr. Gray to have the same relations to *Nerita* and *Trochus* that *Cyclostoma* and *Helicina* have to the Periwinkles. They differ from the true Pulmonates in having the mantle free from the nape, leaving the breathing cavity open. They differ from *Helicina*, &c., in having glassy teeth in complex pattern like *Trochus*, and in having no operculum; in which respect they resemble *Stomatia*. The mantle is unadorned, as in *Nerita*; and, like it, has the power of absorbing the inner whirls of the shell. On the other hand, it is said to be unisexual, in which it resembles the Pectinibranchs rather than the present order. The group is West Indian, and contains two genera: *Proserpina*, in which the whole shell is glossy, like *Pupina*; and *Ceres*, in which it is keeled, and only the lower region is polished. In both there is a lump on the pillar, as in *Rotella*; and there are spiral ridges inside the mouth.

*Family SCISSURELLIDÆ. (Slit-Top Shells.)*

Till lately it was believed that there was no living representative of the vast tribe of palæozoic and secondary *Pleurotomarias*; except the tiny little shells of *Scissurella*, which resemble a *Vitrinella* with a slit in the mouth, or a spirally curled *Emarginula*. The tiny animal has been examined, and found greatly to resemble *Cyclostrema*, having very highly developed pinnate feelers at the sides. In some species the slit of the young shell is afterwards closed into a hole; in others, the hole is seen in the earliest stage, and is moved on as in *Rimula*.

But the true *Pleurotomaria*, which was believed to have passed away before the Tertiary age, is now known to be living, a beautiful specimen having been dredged in deep water near the island of Marie Galante, so like the Oolitic forms that it might, if fossilized, have passed for one of their race. It is exactly like a pearly *Calliostoma*, with a slit lip. More than four hundred fossil species are known, some of them as large and solid as the *Turbos*, some as inflated and thin as *Scissurella*. In form they vary from *Elenchus* to *Euomphalus*, and are either keeled or rounded at the base. In *Trochotoma* there is a hole behind the lip, instead of a slit. In *Polytremaria* there is a row of holes in a spiral necklace, as in *Siliquaria*. The shells of the palæozoic group *Murchisonia* are elevated like a *Melania*; while those of *Schizostoma* are depressed like a *Euomphalus*, with a doubly waved lip like *Terebralia*. Another palæozoic form, *Catantostoma*, has the last whirl twisted downwards. The closely allied shells of *Scalites* and *Raphistoma* are very thin and depressed, with the whirls keeled and the outer lip pinched but not slit.

?? *Family MACLUREADÆ.*

Of several other palæozoic forms, even the family position is as yet doubtful. One of the most singular is *Maclurea*, a *Euomphaloid* shell



characteristic of the Chazy limestone, in which the solid operculum has an upright support, as in *Jeffreysia*. It is supposed by some to be related to *Bellerophon*. It is very difficult to determine the relations even of recent shells, when the animal has not been seen, because the shells of such different mollusks are very like each other. Much less can we expect to understand the relations of abnormal fossils, when even the texture affords no clue, and the peculiarities of the mouth can be so seldom examined.

*Family HALIOTIDÆ. (Sea-ears or Ormers.)*

The very beautiful group of ear-shells may be regarded as *Turbos* flattened out to adhere to rocks. They present however several characteristic differences of structure. There are two gills and two auricles, instead of one as in the Top-shells; and the foot is greatly dilated and very strong. They adhere so tightly to the rocks that they are often forced off by the point of the bayonet. The best way to loosen them is to pour warm water on, and then jirk them with the foot. They are often cooked; and the shells, which present a very brilliant nacre, golden, green, orange, pink, &c., according to the species, form a regular article of trade for ornaments and inlaid work. The muscular attachment, instead of being horseshoe-shaped, as in ordinary univalves, is round and central as in the oyster. There is always a ridge along the back, with a few holes near the edge. These are filled up as new ones are made. Below them is a slit in the mantle to correspond. The foot is very elegantly fringed, and the teeth are complicated as in the Top-shells. The *Haliotis* tribe are rare in the tropics; but abound in Japan, California, and Australia, and are found along the east coast of the Atlantic. Their absence from the whole of the South and tropical America and the eastern shores of North America, is very remarkable, seeing that they abound from Kamschatka to Cape St. Lucas. The shells of *Padollus* have a second spiral rib, but without perforations. In *Teinotis*, (the *Ass's Ears*,) the shell is thin and glossy; the animal being very active, with a large foot. It is thought that the number of holes is constant in each species; but this is very far from being the case. In the Californian species, they vary from two to four, and from five to ten.

*Family FISSURELIDÆ. (Key-hole Limpets.)*

In this large and beautiful family the body is symmetrical, and only spiral in the first stage. There are two gills at the back of the neck, one on each side of the shell, the vent being between them. This discharges, in the sea-ears, into the last hole: in this family into a hole or slit which is variously situated in the different genera. The foot is large and more or less fringed, as in the preceding families; but the shell is not pearly, and there are no eye-stumps. As in all other Limpets, (with which however they have not a very close connection,) the muscle is horseshoe-shaped. The teeth are arranged in complex patterns, as in the preceding groups. They are found on all shores, though sparingly. The largest species are from South America. The shell of *Kimula* is nearly related to *Scissurella*, but is formed in

a flat spiral, with a rapidly enlarging mouth. The hole is behind the outer lip, as in *Trochotoma*, and is gradually brought forward, the part behind being filled up. The animal must therefore have the power of eating out its anal orifice, as it grows older. The shells are found fossil in the oolites, living in the East Indian archipelago, and in the Gulf of California. The boreal form *Puncturella* resembles it, but with a plate inside to support the anal siphon which is rather long. The young shell of *Glyphis* exactly resembles *Rimula*; but as the animal grows, it becomes conical; and instead of moving the hole, it enlarges it where first formed, till at last the whole of the spire is eaten away. The animal is larger than the shell, which is always prettily cancellated, and crenulated at the edge. In *Fissurella* proper, the spiral nucleus has not been detected, even in very young shells. The animal can be entirely drawn into the shell. In most species, the shape is very constant; but in some, there is great irregularity, not only in the form of sculpture, but even in the shape of the hole. A curious specimen from Mazatlan has two holes; and another still more extraordinary one, found in Chili by D'Orbigny, has none. *Clypidella* has a singular, flat, waved shell, with a narrow key-hole. *Macroschisma* has a slug-shaped body, projecting in front of the shell; which is oblong, with a very large hole behind. The great *Lucapina* of the Californian coast has an animal as large as a dinner plate, almost covering a flattened crenulated shell. *Fissurellidæa*, from the Cape of Good Hope and Tasmania, has a very similar animal and shell, but with a smooth border. The shell of the African *Pupillæa*; also covered by the mantle of the animal, has a sharp, smooth edge.

Another group have the anal orifice in front. *Emarginula* has a shell like *Rimula*, but with a slit in the outer lip like *Pleurotemaria*. The shells are always sculptured, and are from deep water. Fossil species first appear in the Trias. In the group *Hemitoma*, the slit is very small; and in *Clypidina*, it is simply a wave. In the "Duck-bill Limpets," *Parmaphorus*, the shell is white, and almost covered by the black mantle, under which is an enormous foot: there is only a broad wave for the excretory passage.

In the remaining families of the Scutibranchs, no tendency has been observed to spiral developments, even in the young shell. There are no fringes to the mantle margin; and the animal is generally of sluggish habits, and covered entirely by the shell. The teeth also are formed on a much simpler plan, consisting of a few longitudinal series, of variable form.

#### *Family GADINIADÆ.*

A small family of shells, from the west coasts of the Old and New World, have characters in common with the *Siphonariæ*, or air-breathing Limpets. A groove is seen within, proceeding from apex to margin on the right side, going over the muscular scar. This is probably for the vent, as in the last family. But there is only one gill, placed sideways across the back of the neck; and the tentacles are funnel-shaped. None of the species are colored. They often adhere to other shells, eating out cavities like the Cap-limpets. The west American

form, described as *Gadinia pente-goniostoma* has been found with six, five, four, three, two, corners, or only one; or quite round, which is its normal state. So much may we err by describing from single specimens.

*Family* ACMÆIDÆ. (*False Limpets.*)

The shells of all the Limpets are so like each other that no characters have yet been found to distinguished them generically. But the accurate Russian naturalist Eschscholtz, when examining the Limpets of the Californian coast, found that they differed materially from the true Limpets in the shape of the gill. While the ordinary Rock-limpets have the gill greatly developed, going all round the margin of the shell, as in the oysters, these deeper water species have one small gill on the left side of the neck, like the Top-shells. The teeth also are in rows of not more than six each. It would have been very convenient if these very different gills had left their different marks inside the shells; but all the fancied marks turn out fallacious; the animals of reputed *Acmaeas* turning out to be Limpets, and *vice versa*. Further, among the single-gilled Limpets, there are now found considerable differences; the large *Tecturina grandis* of the Californian coast being the type of a separate group. The white, conical *Scurria mitra*, which makes holes for itself in the roots of sea weeds in the west temperate regions of both North and South America, (avoiding the intermediate tropical region,) has a fringed mantle, looking like a gill, all round the inner edge of the shell. The shells of the beautiful group *Scutellina* are thin, finely sculptured, and very glossy inside. They often have a rudimentary pillar lip, like *Navicella*, which caused the west American species to be described by Prof. C. B. Adams as a *Crepidula*. The little Scotch *Pilidium* has a somewhat similar shell. The animal of the boreal *Lepeta* is blind; its teeth are curiously ornamented like a stag's head.

*Family* PATELIDÆ. (*True Limpets.*)

The largest known Limpet (*Patella mexicana*) inhabits the rocks of west tropical America, growing to be a foot across, and of capacity large enough for a French lady's wash hand basin; else, this tribe, so abundant elsewhere, is remarkably absent from North America. The rocky shores of the Old World are covered with them, almost always above the region of the Acmaeids; sometimes at such high levels that they can rarely be dashed over with sea water or find anything to eat. Like the Ear-shells, they adhere very firmly to the rocks when once touched, by means of their strong muscular foot, grooved across the middle. The tongue of the common English Limpet is longer than the shell itself; containing 160 rows of twelve teeth each, or 1,920 little glassy hooks. With these it rasps the nullipore and sea-weed, principally in the night. It has the organs both of adhesiveness and inhabitiveness large, growing according to the shape of the rock which it selected, and where it always returns to roost. In one county of Scotland twelve millions have been collected in a year for bait; and near Larme, in Ireland, many tons' weight are annually collected for

food. The gill goes round both head and body, just under the shell; and is ornamented with very beautiful fringes, sometimes of two hundred filaments. One of the south African Limpets, *Olana*, has a snout in front of the shell; but whether the animal has any coördinate peculiarity, has not been ascertained. The shells which Messrs. Adams call *Cymbula* are believed to be only True Limpets altered into a compressed form to living on stems of plants. The *Nacellæ*, or horny, Sea-weed Limpets, alter in form in the same way. They have the gill interrupted over the head, forming a transition to the Acmaëids. The shells of the African *Helcion* are like an *Emarginula* without slit.

Fossil Limpets are found in rocks of all ages; but of course their generic position is uncertain. The Limpets, more perhaps than any other shells, require to be studied geographically, with careful dissections of the animals, and with diligent comparison of a large multitude of specimens.

The last family of this order presents special characters so different from any other mollusks, that if they alone were attended to, it would be necessary to form a class for their sole occupation. Nevertheless, they have so much in common with the Limpets that they are generally included in this order.

*Family* CHITONIDÆ. (*Coat-of-Mail shells, or Sea-woodlice.*)

It has been well said that the *Chitons* have their backs armed, like the Isopod Crustaceans; their gills, like those of the Brachyurous Crustaceans; their heart, in a long vessel down the back like a Sea-worm; their reproductive organs symmetrical and repeated on each side, like the bivalves; a crawling foot and head, like a Limpet; a posterior vent, like the *Fissurellas*; and a leathery skin, like the *Tunicaries*. According to the old-fashioned division of shells into univalves, bivalves, and multivalves, they were driven by Linnæus to keep company with the headless *Pholas* and the Crustacean *Lepas*. For they have eight distinct shelly plates, fitting over each other like tiles, the middle ones marked off in sculpture by diagonal lines, and all of them let into the tough mantle by sharp smooth edges, like *Pupillea*. Outside, the creatures have a general resemblance to the bodies of Trilobites; and, like those strange denizens of the palæozoic seas, or the living Woodlice, they can roll themselves completely up into a ball. The eight valves and the skin together may be taken to represent the shell of the Limpet. Underneath is a small head, with mouth, jaws, and long armed tongue, the teeth being arranged in very peculiar patterns. The young *Chitons* have very little resemblance to their parents. They are divided into two nearly equal parts, head and body, with a pair of eyes between. There is no trace of foot, gill, or even mouth; nor of the swimming fins almost universal in young marine Gasteropods. They appear to change their fluids and grow by suction, and to move by a fringe of feelers round the neck. Presently however the body half develops lines on the back, between which gradually seven of the valves are formed, the shelly matter first appearing in granules, as in the land snails. At the same time a foot

spreads out below, and gills between the upper and lower portion. These gills are not like the single long gill of the Limpet, curled round; but are two long, symmetrical organs; it being the fashion of Chitons to double almost everything, the generative orifices included. The head gradually becomes smaller in proportion, is covered with granules which become the eighth valve, and develops a slit, which becomes the mouth. It then loses the eyes; the head never stretches beyond the valves, and there are no tentacles.

The *Chitons* live chiefly on rocks and under stones at low water and in moderate depths. They are sluggish creatures, and apparently neither disturb others or are themselves disturbed, (except by conchologists.) They are found in all seas; but the finest species are not found in the tropics. The largest are from the colder western rocks of North and South America. Different as the *Chitons* are from all other living creatures, they are very like each other. The different groups are not generally confined to particular shores; but the *species* do not travel so far as Limpets and ordinary mollusks, as, indeed, we might suppose from the young having no swimming fins. A large number of genera have been proposed by modern authors, of which the following are the principal; writers unfortunately not agreeing on the group for which the old name should be retained.

The true *Chitons* have the mantle covered with smooth scales, and the end valves elegantly pectinated at the edge; the back valves having the apex raised. *Enoplochiton* has the scales long and unequal; the back valve with smooth edge and depressed apex. In general the middle valves have only one notch; but in *Radsia* there are two; and in *Callochiton*, the edges are cut into four bifid lobes. In *Lepidopleurus* the valves are thin, and easily fall off; the insertion-plates being inside the colored parts. The mantle-scales are extremely small. In *Leptochiton*, which includes most of the northern forms, the scales are minute, the gills short, and the insertion-plates rudimentary, without notches. In *Lorica* and *Schizochiton*, the mantle and last valve are slit behind. They have very minute scales, and in the latter group the valves are very small as compared with the mantle.

In the next series, the mantle is covered with thick hairs or bristles. *Acanthopleura* has the insertion-plates pectinated. *Corephium* has the mantle-spines shelly, and the back valve not lobed at the sides. *Mopalia* has the mantle much produced in front, and narrowed behind.

A comparatively small group *Tonicia* has the mantle naked and smooth. One species, in which the valves are more separated, has been dignified by Dr. Gray with the classical generic name *Fannyia*.

The Oregon district produces a curious group of *Chitons*, in which the valves are nearly or entirely covered by the fleshy mantle. The commonest species, which was first sent to the British Museum by Lady Katherine Douglas, and therefore called by Dr. Gray *Katherina Douglasiæ*, (*Anglicæ*, Douglas's Catherine,) has the valves partly exposed and the skin smooth. The giant *Cryptochiton*, the anatomy of which has been so carefully described by Dr. Middendorff, has gritty particles in the rough skin. There is no sculpture on the valves,

which are quite hidden ; the creature looking outside only like a lump of leather.

Another main division of the *Chitons* contains creatures which have pores in the mantle margin ; always nine on each side, and armed with bristles. The great *Plaxiphora* of the Cape Horn district has irregular bunches of bristles, some of them shelly. The shells of *Acanthochites* are beautifully adorned with regular tufts of bristles, which are often of pearly hue. *Amicula* is almost covered by the hairy mantle, like *Cryptochiton*. In *Cryptoconchus*, the tufted pores are at a distance from the edge ; and the exposed parts of the valves are extremely narrow. Lastly *Chitonellus* has a long, narrow, fleshy, slug-like body ; with very small and separate valves, adapted to crawl in the crevices of coral rocks.

Valves belonging to the *Chiton* group have been found in most geological periods, from the Silurian age downwards. In one of the Silurian forms, called *Helminthochiton*, the valves were separate from each other, but not covered by the mantle.

#### ORDER CIRROBRANCHIATA. (*Tuft-gilled Crawlers.*)

##### *Family* DENTALIADÆ. (*Tusk-Shells.*)

The tooth-shells form a very peculiar and degraded group, which it is the fashion to arrange near the Key-hole Limpets, from the fancied analogy of the tubular shell to a drawn-out Fissurella. They have however scarcely anything in common with that beautiful family, and very little with the class of Crawlers. The very Vermetids look down upon them ; for they have heads, tentacles, and eyes, while these have none. The animal is scarcely raised above the bivalves, except that it feeds upon them. The foot is conical and funnel-shaped, opening into the stomach, which is armed with a gizzard, as in the *Bullas*. In fact they belong rather to the Opisthobranchiate division, the fringe-like gills being behind the heart. The blood is red, as in the worms : the breathing organs symmetrical, as in the *Chitons*. They have however a lingual ribbon, in three series, on a very simple plan. They live in rather deep water, where they prey on Foraminifera and small bivalves. Just as the shell of *Vermetus* resembles *Serpula*, so the shell of *Dentalium* often might be mistaken for *Ditrupa*, also a sea-worm. The *Ditrupas* however generally have a swelling behind the mouth, while that of the tooth-shells is plain. In the group *Entalis*, there is a slit at the side of the anal hole. Often a small tube is protruded beyond the hole, which is not a constant character, even in the species.

#### SUB-CLASS PULMONATA.

##### (*Air-Breathers.*)

We have already passed under review many of the air-breathing mollusks, which by their general affinities seemed more nearly related to the marine tribes. The mere fact of crawling on land rocks and plants instead of river and shore ones, does not necessarily imply any great

diversity of structure. Between the habits of the amphibious Periwinkles, which crawl half a mile from shore, and the Marine Snails which are always picked up with sea shells; or between those of the freshwater snails and freshwater Periwinkles, which are found entangled in the same group of confervæ; there need not exist any essential difference. The animals of the true Pulmonates however are formed on a lower type from those of the ordinary Sea-crawlers. The senses are less acute; and the individuals perform the functions both of male and female to each other. The breathing cavity, instead of being open, as in the air and Water-breathing Prosobranchs, is a chamber lined with minute blood-vessels, and open only at a small hole. This is closed by a valve, to shut out the water in the aquatic tribes, and the hot dry air of summer days in the land species. The shape and way of crawling of the snails is too well known to need description. They are all fond of moisture, and more or less slimy. In the extremes of heat, cold, and drought, they shut themselves up in corners or under ground, and often make a false operculum, pierced with a minute breathing hole, which is thrown off when the genial season begins. In damp mornings and evenings they are in their glory, munching the luxuriant vegetation, and leaving their slimy track behind them as they crawl. They were esteemed a great delicacy by Roman epicures; and are still extensively eaten, both in Europe and South America. The young snails do not undergo any transformation, like that of the pteropodous infants of the Sea-crawlers; their diffusion being sufficiently provided for by ordinary locomotion. Snails are found everywhere, from the Arctic regions to the equator, but are rare in dry and silicious districts, plentiful wherever there is lime and moisture. The continental species are diffused over very wide areas; but the islands of the tropical seas have each their own peculiar forms, even if very near to each other, or to the main land. Supposing a traveler brought back the snails from a West Indian island, an experienced conchologist could tell at once where they were collected; but it would be almost impossible to tell the same from the vast expanse of the various United States.

Snail shells are always lighter than sea shells, having to be carried on the back of the animal without the watery support. Their construction is much simpler, abounding in animal matter; and they are first formed, like the *Chitons*, by shelly granules deposited in the horny layer. Some of the groups are ovoviviparous. The great Brazilian snails lay eggs with hard shells, as large as a pigeon's. In some groups, the shell is little more than horny skin; and in many, the animal is too large to be withdrawn into it. Some families indeed have no shell at all, or only a plate protecting the most delicate organs. The tongue-membrane is not a long ribbon as in the sea-shells, but a short broad horny layer; partly spread over the soft tongue partly curled up at the side. It is covered with an enormous number of minute square teeth, very similar in pattern, and looking not unlike a tessellated pavement, with raised knobs.

TRIBE I. GEOPHILA, *Land Snails.**Family* HELICIDÆ. (*True Snails.*)

The true snails have their body distinct from the foot, and protected by a spiral shell. The shape of this is extremely variable, presenting differences much greater than is usual between widely distinct families in the marine tribes. Yet the different forms pass into each other by such insensible gradations, and the animals are so like in all essential particulars, that the division into genera is a matter of great difficulty. There are many myriads of species from all parts of the globe, and from all kinds of habitats. Many species have been found on mountains from 8,000 to 11,000 feet high, both in the Old and New World, while others live in marshes, or on the sea-shore. In some few groups, both animal and shell present well-marked peculiarities; others are restricted to special districts; but in general the sections are constituted for the convenience of identifying species. How long the snails have lived on the surface of our globe it is impossible to say, as the remains entombed in rocks are almost exclusively of aquatic productions. Nevertheless many snails have been washed down into tertiary strata; and it is singular to find forms and even species now peculiar to the New World, such as *Megaspira*, *Proserpina*, *Glandina*, and *Stenotrema*, fossil in the European Eocene; showing that existing forms have long outlived existing continents. The oldest snail known is a little *Pupa*, found by Prof. Dawson, in situ, on the fossil trees in the coal measures of Nova Scotia; generically it exactly resembles existing forms.

The "horns" of the snails are in reality very long and sensitive eye stumps. The true tentacles are short, and nearer the mouth. They have a saw-like upper jaw to bite the leaves, and plain teeth arranged in squares. The nose, or lung valve, is just under the right side of the shell; the reproductive orifice under the right eye stalk. Some of the European species form and dart out minute needles, it is supposed to attract their mates. The old genera of Lamarck may be taken as sections, from which the immense multitude of species now known require to be subdivided.

The true snails have a short spire, and a mouth rather broader than long. The eatable snail, *Helix pomatia*, (which is believed to have been introduced into South Britain by the Romans for epicurean purposes,) and its congeners, have a semicircular mouth and rather thin lip. *Eurycratera* has a thin shell and very capacious body whirl. *Helicostyla* comprises the tall, compact snails of the Philippines. *Acavus*, which abounds in the Old World, has the mouth somewhat produced in front, and the lip thickened all round, without umbilicus. The group *Caracolla* has the lip continued all round, the spire flattened and generally keeled. In *Lucerna* the mouth is more or less twisted, with teeth; and in *Anostoma* the adult shell is turned upside down, the mouth joining the apex. *Lychnus* is an Eocene *Anostoma* without teeth. *Tridopsis* contains the ordinary American toothed snails; the flat, many-whirled forms being called *Polygyra*. *Geotrochus* contains the conical, thin, flat-based snails, shaped like *Calliostoma*. *Solariopsis* contains the snake-skin snails of tropical America. *Macrocyclus*



resembles it in form, with swelling whirls, and circular expanded mouth. *Iberus* is a common group in the Mediterranean region, also found in California; flattened, often keeled, with the mouth bent downwards. *Ochthephila* abounds in the Canaries, with the lip continued all round, as in *Caracolla*. *Hygromia* contains the small, flat, umbilicated snails of temperate regions, with sharp, rounded mouths, thickened within.

The *Helicella* tribe have the margin quite sharp, and the shell thin and glossy. They live in dark, damp places, and are remarkable for the lingual teeth being pointed at the sides. The shells of *Discus* resemble them, but are not glossy. Those of *Zonites* are rough above but glossy below. The curious Jamaican group *Sagda* has a stumpy, elevated shell, with many whirls, and laminae running along the inside of the base. *Pityis* is angular, with the mouth variously toothed. The shells of *Stylodonta* have the pillar twisted like *Achatinella*; and those of *Streptaxis* have the pillar curiously distorted.

The *Bulimus* group are like snails drawn out into an oval, the spire being raised, and the mouth longer than broad. There is generally a plait or fold on the pillar. The typical *Bulimi* of South America are six inches long when adult, and an inch when born. Their eggs resemble a pigeon's. The animals are exactly like those of the typical snails. *Cochlostyla* is a Philippine group, with the mouth somewhat rounded and passing into *Helicostyla*. The shells of *Orthalicus* are thin, with a sharp lip; those of *Bulimulus* approaching *Pupa* in form. The *Partulas* are an ovoviviparous group, living on low bushes near the sea in the Pacific islands. *Otostomus* is a South American group, with very long narrow mouths. The shells of *Odontostomus* are curiously toothed, like *Pupa*; and *Tomigerus* has a wry mouth, twisted upwards as in *Anostoma*. The shells of *Cochlicella* are many whirled, like *Cylindrella*. *Chondrus* has a tooth close to the suture. *Zua* is glossy like *Helicella*. *Azeca* resembles it, with a ringent mouth. The shells of *Bostryx* have the last whirls separated, as in *Vermetus*.

The *Achatina* group resemble *Orthalicus*, with the bottom of the pillar truncated like *Melanopsis*. The typical species are African, and are the largest land shells known, being eight inches long. *Limicola* forms a transition to *Orthalicus*, with the pillar pinched, not truncated; and *Pachyotis*, a group which lingers in the islands of the South Atlantic, forms a similar transition to *Odontostomus*. The West Indian group *Pseudotrochus* has a porcellanous, highly painted shell. The group *Columna* is many-whirled, like *Cochlicella*. The little *Cionellas* are glossy, and scarcely truncated. *Spiraxis* has the pillar bent; and the large group *Achatinella*, which culminates in the Sandwich islands, and is ovoviviparous like *Partula*, has a sharp, twisted fold on the pillar, instead of a truncation. *Tornatellina* nearly resembles it, but with additional plaits.

The *Chrysalis* snails are remarkable for being narrowed at each end. They are all rather, and some extremely small, and have many whirls. The foot is very short; and the true tentacles very small or altogether wanting. The *Pupas* are very stumpy shells, generally ribbed outside; and with the mouth often curiously distorted by plaits.

In the animals of the little wry-mouthed *Vertigo*, the tentacles can-

not be seen. *Boysia* is a *Pupa*, with the mouth turned up, as in *Anostoma*. *Gibbus* is a group of irregular shells, intermediate between *Pupa* and *Bulimus*. The shells of *Clausilia* are drawn out at each end, and are always reversed. The animals have the great peculiarity of having a kind of operculum (*clausium*) which moves on a leathery hinge, and fits between the teeth of the mouth. They greatly abound in the old world; but only three species have been found in the whole of America. They are represented in the West Indies by the beautiful group *Cylindrella*, in which the mouth is round and the lip reflected. The upper whorls, which would make the shell too long to be carried, are generally thrown off; but the mouth in some species is produced to so enormous a distance that the animal must carry its shell poised in the air, like a pole held at one end. The polished *Cylindrellas* are called *Leia*, answering to *Zua* among the *Bulimi*. The little reversed shells of *Balea* are like a young *Clausilia*; and *Megaspira* is like a very produced *Pupa*, with plaits on the pillar.

The next group consists of snails, which, though they do not live in the water, are never found far off. Their eye-tentacles are short and stumpy, and the animal is fleshy, and not fully drawn into the shell. This is scarcely calcareous, being rarely more than a spiral skin, generally of an amber color. The *Succineas* are very common in marshy places, and easily known by the very loosely spiral shell, with long mouth and pointed spire. *Amphibulima* has the mouth expanded and pinched at the top. *Simpulopsis* has more the shape of ordinary snails. In *Helisiga* the spire is extremely small; and in *Omalonyx* it is almost obsolete, the mantle of the animal being reflected over the sides, as in *Vitrina*.

#### Family VITRINIDÆ. (*Glass-snails*.)

The *Vitrinas* are intermediate between snails and slugs. They can never entirely enter their shells; and, when they crawl, the sides of the mantle more or less overlap the edges. The shells, like those of *Succinea*, are little more than spiral skins, and are generally snail-shaped, and green. A passage to the true snails is provided in *Pfeifferia*. In *Daudebardia*, the tail is very short; the little shell lying at the back of the animal, as in *Testacellus*. The shell of *Peltella* is shaped like the Sea-ears, and is entirely hidden by the mantle. *Cryptella* is the slug of the Canary Islands, which hides itself the greater part of the year, and then makes sad havoc of the gardens in the rainy season. It has an irregular shell, which in the very young state is provided with an operculum; but afterwards it is entirely covered by the mantle-shield, on the back of the broad animal. The African tribe *Parmacella*, have a similar shell, similarly hidden. The foot is truncated behind, thus passing into the next group.

Some of the *Vitrinas* have the tongue-teeth hooked at the sides, and are supposed to feast on animal substances. The *Stenopus* tribe however have a horny, saw-shaped jaw and teeth, after the model of the true snails. They resemble the *Vitrinæ* in having mantle-flaps partly covering the shell; but differ in having the foot truncated behind, with a slime-gland at the end. The shells are horny and polished

like *Helicella*. The large tropical group of *Nanina* have the sole of the foot broad. In some of the sections, the shell is rough above. In *Arioptranta*, there are no mantle-flaps, but the slime-gland is still seen behind the left-handed shell. *Helicarion* has a Vitrinoid shell, nearly enveloped by the flaps of a Naninoid animal. The animal of *Paryphanta* is not known; but the shells are like a large horny *Vitrina*.

*Family TESTACELLACIDÆ. (Carnivorous Snails.)*

The great *Glandina* of South Carolina, and its congeners, have the lingual teeth in curled rows and sharply hooked. The head is short, and the lips are produced into false tentacles, as in the *Ampullarias*. The shell resembles a flattened *Achatina*. It is strictly carnivorous in its habits.

A curious little group of slugs are found to have similar dentition and habits. The teeth are pin-shaped. They are known from the common slugs by not being slimy; living under ground, where they prey upon earth worms; and having a little solid shell like a Sea-ear on its tail. Its head however is shaped like the True Slugs. A similar, but somewhat apocryphal slug is figured by Férussae, with a horny, conical shell on the tail; it is provisionally called *Plectrophorus*.

*Family LIMACIDÆ. (Slugs.)*

The True Slugs have teeth very like *Vitrina*, but the points are longer. The body of the animal is united to the foot, and a shield is seen on the back, under which, in *Limax*, there is a calcareous plate, which has been found fossil in the Eocene beds. They are pretty active in damp weather, and love to feed on decaying animal and vegetable matter. The Teneriffe Slug, *Phosphorax*, has a bright green spot on the tail, which shines at night like the glow-worm. In the *Philomycus* of the southern States, the shield covers the whole back of the Slug.

The *Arions*, or Land-soles, have only a few granules instead of a shelly plate, and have a slime-gland like *Nanina*. The common English species has 160 rows of teeth on its tongue, with 101 denticles in each row. They freely eat dead worms; and, like true cannibals, will not refuse to finish off an injured individual of their own species. The Irish Slug, *Geomalacus*, has a shell like *Limax*, and a gland like *Arion*. The reproductive orifice is under the right eye-stalk, as in the True Slugs; in the Land-soles, it is just below the breathing valve.

A very curious New Zealand Slug, *Janella*, resembles *Philomycus* in having the mantle produced over the whole back; but the eye-stalks are behind the forehead, and the mouth beneath, at the front of the foot-sole; so that the head is hardly distinct. The mantle is grooved down the middle, and the breathing hole is half way down the body. The creature coils itself round to sleep like a cat.

*Family ONCIDIADÆ. (Rough-Slugs.)*

The *Oncidia*, like the *Auriculus*, live in damp places near the sea or

ivers. They are short, stumpy creatures with a rough skin, and closely resemble some of the Sea-slugs. Their eyes are at the end of the stalks, which are not retractile. The teeth are like those of snails, but they have no horny jaws. The breathing hole, vent, and ovary are at the back of the body; the intromittent opening under the right eye. *Oncidella* has flaps round the mouth. *Peronia* lives on shores, moving up and down a few feet above tide level. These Slugs have knobs or excrescences on their backs, as well as flaps round the mouth. The British species is said to have the heart in front of the lung, while in all the other pulmonates it is behind.

The *Veronicella*, which lives in damp, shady forests, has a smooth, leathery mantle, and a pair of small, bifid tentacles in addition to the eye-stalks. The ovary opens half way down the side. These Slugs crawl quickly, and are not slimy. They lay their eggs in a coiled necklace.

## TRIBE II. LIMNOPHILA. (*Aquatic Snails*.)

The amphibious tribes differ from the true land snails in having no eye-stalks. The tentacles are generally short and stumpy, and the eyes are fixed at their bases, as in the Periwinkles. The tongue-teeth greatly resemble those of the snails.

### *Family* AURICULIDÆ.

The *Auriculas* were long regarded as sea-shells. They inhabit salt and brackish marshes, and their shells are much more solid than is usual with land-shells. Some of them absorb the inner whirls like the Nerites. The shells always have narrow mouths, more or less toothed.

The typical *Auriculas* sometimes have large shells, and increase half a whirl at a time. They have a stumpy spire, long narrow mouth, thickened inside, and a few large folds on the pillar. They rejoice in mud banks in the East Indian archipelago. The animal of *Cassidula* has the foot cleft behind. The shell is stumpy, and the thickening of the outer lip wrinkled. The shells of *Scarabus* are conic and rather thin, being adapted to a true terrestrial life. The whirls have two rows of indistinct varices, and the mouth is strongly toothed on each side. The little *Alexias* represent the previous groups in the Atlantic regions: having a plain and pointed spire. The tiny *Carychium* resembles *Pupa* in form, and lives in moist places far off from the sea.

The *Melampus* tribe enjoy sea bathing, though strict air-breathers. Their foot is cleft behind. Their shells resemble *Cassidula*, but the outer lip is either thin or regularly toothed within. Some species, called *Tralia*, are said to have a pointed foot. The tentacles in these animals are sharper than in the less aquatic species. The Sandwich Island group *Læmadonta* have a curious plait across the outer lip. The shells of *Leuconia* have a sharp outer lip; and the animal is said to differ from *Alexia* in having the foot grooved across. The shells of *Pedipes* have a very wry mouth like *Scarabus*, and a very short spire. The animal has a grooved foot, and loops in walking like *Truncatella*.

It steps about, more quickly than most mollusks, in rocky crannies on the sea-shore.

*Family OTINIDÆ. (Ear Snails.)*

The little shell of *Otina* could hardly be distinguished from *Velutina* but the animal closely resembles *Auricula*. The tentacles are very small; the foot grooved for looping; and the mouth cleft vertically. The little creatures live in the same situations as *Pedipes*.

*Family LIMNÆIDÆ. (Freshwater Snails.)*

In company with *Melantias*, *Paludinas*, and other gill-breathing freshwater Periwinkles, are found in every part of the globe shell-fish which never leave the water, and yet are as truly air-breathers as the whales. They must needs come to the surface occasionally to breathe, where they may be seen gliding upside down, and sometimes letting themselves drop at the end of a glutinous thread. They have short, stumpy tentacles, with eyes on the inner basis, and very broad feet. They abound most in temperate regions. The breathing hole is at the right side of the neck: the vent at the left. They lay their eggs in gelatinous masses on the leaves of water plants which they devour. The *Limnæa stagnalis* has 110 rows of 111 teeth each, and is said to prefer feeding on decaying animal matter. The shells of *Limnæa* are thin, with a pointed spire, and a fold on the pillar. Those of *Chilina*, which inhabit the clear running streams of South America, are almost exactly like *Auricula*, which the animals of this family greatly resemble. The shell of *Amphipeplea* is transparent and swollen; and is nearly covered by the sides of the mantle.

*Family PLANORBIDÆ.*

The animals of this family differ from the Limnæids in having sharp, pointed tentacles. The shape of the shells is extremely variable. In the first group they are flat, in the second pointed, and in the third limpet-shaped.

*Planorbis* has a spiral shell with the whirls inclosing each other on the same plane. It lives in a reversed position. The whirls are flat and numerous in most of the European species; generally few and swollen in the American. Monstrosities are found, perpetuating themselves in particular ponds, with the spire elevated. The teeth closely resemble those of *Auricula*. One of the minute British species has no fewer than six thousand of them. Some species emit a purple fluid when disturbed. In *Segmentina* the whirls are divided across at regular intervals, by septa with toothed openings for the passage of the animal. So little was known of its true relations in earlier times, that the British species was called the "Freshwater Nautilus."

The *Physa* tribe have shells looking like reversed *Limnæas*. In the typical species they are enveloped, as in *Amphipeplea*, by the fringed sides of the mantle. In the beautiful group *Aplexa*, the shells are glassy, with raised spires, and the mantle margin is plain and not flapped. *Physopsis* is a south African form, like a reversed *Achati-*

*nella*: and the East Indian *Camptoceras* has the whirls separated like *Vermetus*. Fossils of this tribe, as of *Limnæa* and *Planorbis*, are found as old as the Wealden oolitic rocks.

The limpet-like shell of *Ancylus* is as different from *Physa* as *Broderipia* from *Trochus*, or *Testacellus* from *Glandina*. Nevertheless the animal is even more closely allied. The shell is sinistral, (the point being turned to the right,) and entirely covers the animal; which has much less attachment to it than the Limpets, and can move its long neck freely under its large umbrella. *Velletia* is a dextral shell, with the apex turned to the left, and a somewhat different arrangement of teeth. Both forms are found fossil in Eocene strata. The curious little New Zealand *Latia* has a deck across one end, like the Slipper-limpets. Lastly, the Cuban *Gundlachia* has the knobby apex produced, and the deck broad, so as to resemble some of the small-spined *Neritimæ*, but without operculum. All these curious freshwater Limpet-snails crawl on stones or plants, generally in clear water.

### TRIBE III. THALASSOPHILA. (*Marine-snails*.)

These curious creatures are always found close to the sea. The animals greatly resemble *Auricula*, and have the normal dentition of *Helix*. The inside of the breathing chamber is wrinkled, so that it would appear that neither air nor water would come amiss. The cavity is however closed as in the true snails, and wet sea air is probably most congenial to them. The small tentacles are flattened out into a disk round the head.

#### *Family* AMPHIBOLIDÆ. (*Periwinkle-snails*.)

These creatures have shells somewhat like a *Natica*, with the outer lip somewhat notched, as though for an air passage. They are eaten in New Zealand like Periwinkles, and differ from all other true Pulmonates in having a thin, horny, sub-spiral operculum. There is only one genus known, *Amphibola*, from the Australian seas.

#### *Family* SIPHONARIADÆ. (*Sea Limpet-snails*.)

The *Siphonarias* have solid, conical shells, often overgrown with sea-weeds and nullipores. They are known from Limpets by their irregularity of form, caused by a groove which interrupts the muscle of attachment on the right side; not traversing it, as in *Gadinia*. They are found on almost all tropical shores. There is a large mantle-flap covering up the breathing hole. The tentacles are entirely flattened down into a veil; and the animal has a much plainer appearance than the ordinary Limpets. The individuals in many species vary more, in shape and sculpture, even than in their water-breathing neighbors. These creatures are to the *Amphibolæ* what the *Ancylus* is to the *Planorbis*.

### SUB-CLASS. OPISTHOBRANCHIATA.

The next division of the crawling mollusks consists of creatures which are generally destitute of shells, or simply have them as a pro-

tection to particular organs of the body. The gills are not lodged in a special neck-cavity, but are *behind the heart*. The sexes are united in each individual. In the young state, they are exactly like the fry of the prosobranchs; each being inclosed in an operculated spiral shell, and furnished with pins and *cilia*. They are all inhabitants of the sea. They are formed on two distinct types; those in which the gills are at the side, more or less covered by the mantle, and often protected by a shell; and those in which the gills are exposed, and entirely destitute of shell. They live principally on animal matter.

ORDER I. TECTIBRANCHIATA. (*Crawlers with sheltered gills.*)

Family TORNATELLIDÆ.

The animals of this tribe are as yet but little known. They are arranged by Dr. Gray between *Scalaria* and *Cerithiopsis*, on the supposition that the gills are comb-like and the animal unisexual. It is curious how large a proportion of existing observations on mollusks need verification by those who have honest, well-trained eyes. Just as the infant's eye has to be trained to distinguish forms and distances, so it requires practice before we know how to see truly an object that lies before us. During the educational process it is often very easy to see what we wish or expect to see. The shells of this tribe are nearly allied both to the *Pyramidellids* and the *Auriculids*; and some aberrant forms show relations both to *Ovula* and *Dolium*. As the living forms are confined to a very few species, it is scarcely to be expected that we should be able rightly to assign the positions of the various fossil groups. These are found in great numbers, beginning with the coal strata, becoming very plentiful in the oolites, and culminating in the cretaceous age. The ordinary sculpture of the tribe is in spiral lines or rows of dots. They differ from all the other Opisthobranchs in having a very thin operculum, with broad, thin flaps, so as completely to cover the mouth. The animal is quite retractile into the shell, and has the general aspect of an *Auricula*, with its short, flat, triangular tentacles and the eyes at their front. The teeth however are widely different. Instead of the thousand tessellated teeth of the snails, there are simply two rows of sickles arranged as an arrow head on the narrow, broad tongue. They live in rather deep water, and are by no means common in collections. The tentacles are used rather as a veil than as feelers, being laid over the front of the shell in walking. The gills are at the side, cloaked over by the mantle.

The shells of *Tornatella* proper are thin, with one fold on the pillar. Those of *Buccinulus* are stout, with two folds. (*Monoptygma* may prove to be an elongated *Tornatella*, with a single, slanting fold.) All the remaining genera are fossil. *Acteonina* is like a *Monoptygma* without plait. The oolitic *Cylindrites* have the folds twisted outwards. The chalk *Acteonella* is like a cone-shell with plaited pillar, but without breathing notch. *Cinulia* has a globular shell, with many-plaited pillar, and toothed outer-lip. *Globiconcha* has a similar shell without the plaits. *Varigera* resembles it, with varices like *Scarabus*. In the Portuguese *Tylostoma*, varices are formed thickened inside as in *Cassis*.

*Pterodonta* is notched in front, in which respect it resembles the living *Ringicula*. The shells of this genus are very small, and have been passed on from one place to another, like an English pauper. They have a wry mouth with strong pillar-plates, and a notched lip, somewhat like *Malea*. They probably form a family by themselves, differing from *Tornatella* in their glossy texture.

*Family CYLICHNIDÆ.*

In this tribe the teeth are arranged in thirteen longitudinal series, greatly resembling *Fissurella*. The shell somewhat resembles a *Tornatella* without plaits, with the spire more or less concealed, and the aperture pinched behind, swelling in front. In some of the forms the apex is prominent and reversed, as in Pyramidellids. The tentacles are united into a broad veil, looking something like a *Natica* as the creature ploughs through the wet sand. There are however small eyes in front. The deep-water *Cylichna* has the spire concealed. In the littoral *Utriculus* it is raised; and in *Tornatina* there is a columellar fold, and a channeled suture. Certain little shells, closely resembling *Radius*, have been referred to this family, till more is known concerning the animals. *Volvula* has a posterior canal like the Egg-shells, but a fold on the pillar like *Tornatina*. Some curious fossil forms appear to belong to this group.

*Family AMPHISPHYRIDÆ.*

In this little group the shell closely resembles *Utriculus*; but it is transparent, the eyes being placed behind it, as in *Jeffreysia*. The tentacles also are like side-fins, and the animal shuts itself up entirely in its shell. The teeth closely resemble *Tornatella*, but with a square key-stone between the rows of sickles.

*Family APLUSTRIDÆ.*

The shells of this family are generally very highly colored, and are partially covered by the expanded foot-lobes. The animals, also, are highly tinted, and adorned with flap-like tentacles, with eyes at their bases. The tongue-teeth resemble *Tornatella*; so does the pretty little shell of *Bullinula*, which has a twisted, but not plaited pillar, notched at the bottom. *Aplustrum*, which abounds in the Sandwich Islands, also has a twisted and notched pillar, with a membranous outerlip and flattened spire. In *Hydatina*, the pillar is simple.

*Family BULLIDÆ. (Bubble-shells.)*

The shells of this family resemble an *Ovulum* without canals, and with sharp lip. The apex of the spire is generally perforated, and the shell adorned with cloudy painting. The teeth are in arrow-headed rows of sickles, with a hooked key-stone. The *Bullas* love slimy places, where they grub for bivalves and other mollusks. The shells of *Haminea* are thin and horny, almost inclosed by the broad flaps of the foot and head. *Acera* has a similar shell, but more flattened, with



a slit at the suture, through which a mantle tail runs, as in the Olives. The animal has a very long head, but no eyes. This is also the case with *Atys*, the shells of which are strong, white, and generally notched on each side of the lip.

*Family PHILINIDÆ. (Open Bubble-shells.)*

The shells in this family are never completely rolled-round, but the point of the spire can be seen within. They are situated at the tail end of the animals, which never wholly enter them. The teeth of these creatures consist of two (rarely four) longitudinal series of sharp sickles, turned upwards and often serrated within. Sometimes there are small, buttress-like teeth outside. The animals, like the rest of the Bubble group, have the tentacles merged into the frontal veil, making the head wedge-shaped, for swimming or gliding through soft mud, the resting-place of unsuspecting bivalves. While the blind *Naticas* deliberately drill their hole and suck out the soft flesh, the dull-eyed Bubbles gobble them down, shells and all, and send them to their gizzard-mill to grind. This consists of three shelly plates, much thicker than the shell-covering of the animal, and working together by means of strong cartilage. An old Italian naturalist called the plates of this gizzard *Gioènia*, after himself, and described the habits of the invented animal; so that even Lamarck and Cuvier were deceived by it.

The first group never cover their shells. That of the *Scaphander* is very large and swollen in front; narrow and projecting beyond the blind animal behind. The green, somewhat pearly shell of the Pacific group *Smaragdinella* is placed on the middle of the back; the spire being represented by a cup-like process, as in *Calyptræa*. The creature has its tiny eyes in the middle of the veil. *Phanerophthalmus* has a horny plate, scarcely bent-in on one side for a spire, at the back of the animal, and partly covered by the foot-lobes. *Cryptophthalmus* has a similar shell, with the eyes behind the veil.

In the next group the shell is colorless, and entirely covered by the mantle, at the back of the body. The animals have no eyes. *Philine* has a very open, slightly-spiral shell, *Doridium* a flat, triangular plate. *Chelidonura* has a thin, slightly curved, ax-shaped shell. The animal is very brilliant, with two long tails behind.

The animals of *Gasteropteron* and *Posterobranchæa* require more careful examination. They have no shell, and may belong to another group.

*Family APLYSIADÆ. (Sea-hares.)*

In the remaining families of Tectibranchs, the head is drawn out, and the tentacles are distinct. They present the general aspect of Sea-slugs, and, like their land allies, have often a shelly plate to protect the vital organs. The tongue-teeth are arranged in very numerous longitudinal series, in angular cross lines. The sea-hares are grotesque creatures, which crawl about among rock-pools, living on a mixed diet. They have ear-shaped feelers, with eyes at their bases; a fat body, under the skin of which is an irregular shell, and often rough with

hairy or knobbed ornaments, and produced into a tail; and side-flaps to the foot which may be used for swimming. When disturbed, they discharge a beautiful violet fluid from the skin. The harmless "Unwashables" (*Aplysia*) were formerly dreaded by fishermen, who thought their stains were poisonous and indelible. They have a convex, horny plate covering the gills; and sometimes old Sea-hares have several of these, one inside the other, as in the Cuttle-pens. They have a cartilaginous gizzard, like the Bubbles. In *Syphonota* there is an excretory tube above the tail. *Dolabella* has the plate shelly, and generally ax-shaped.

*Aclesia* is like *Aplysia*, without shell or swimming flaps. In *Stylocheilus* the neck and tail are very slender. *Notarchus* has the body rounded, with a very narrow foot for adhering to floating sea-weed. *Bursatella* presents a most anomalous appearance. The common observer might take it for a jelly fish: for it is quite round, with only a rudimentary foot, and with a mass of branched ornament. This consists, however, first of a large gill hanging out of the back; and secondly, of the tentacles which are cut up into branches.

#### Family ICARIDÆ.

A small family of Sea-slugs have a Bulloid shell, not covered by the mantle, and only two stumpy tentacles, instead of four, as in *Aplysia*. The body is thin, with a very long tail. The shell of *Icarus* resembles *Amphisphyræ*, with a notch at the suture. *Lobiger* has a thin shell shaped like *Pedicularia*, with four spreading foot-laps, adapted for swimming, like the Pteropods.

The remaining families differ from the Bubbles and Sea-hares, in having the reproductive organs close together, in one tubercle.

#### Family PLEUROBRANCHIDÆ.

These animals have four stomachs, but very short intestinal canal. They are sluggish, compact, often large, and have a somewhat retractile proboscis. The head is hidden under the edge of the mantle, with two tentacles and eyes. The gill is at the side, not on the back as in *Aplysia*. *Pleurobranchus* has a thin, flat horny shield, and a very large foot. The mantle in *Oscanius* is irregularly expanded, and the shield silvery. *Susania* has a plain body, with very small shield, and a large mantle deeply notched in front.

*Pleurobranchœa* and *Neda* have no shield, and a very small mantle. The former has a narrow, the latter a broad foot.

#### Family UMBRELLIDÆ. (*Chinese Umbrella Shells.*)

Again we come unexpectedly on a group of Limpets; for so the shells might be considered. The *Umbrellas* are very large creatures, wearing a flat limpet on the middle of the back; not immersed in the mantle, as in the very differently organized *Lucapina*. The gill is below the shell, on the right side. The foot is enormously large, and encloses not only the body but the head, which has a retractile snout. Fossil specimens have been found in the Eocene beds. The animal of

*Tylodina* is intermediate between the *Umbrellas* and the *Pleurobranchs*. The head is produced and cleft in front; the foot small; and the shell shaped like *Scurria*, but membranous, and with a small spiral, sinistral apex. This will probably be hereafter detected in the young *Umbrellas*.

*Family RUNCINIDÆ.*

The *Runcinas* are tiny Sea-slugs, with gills like *Pleurobranchus*, and hard gizzards like the Bubbles. The tentacles are flattened into the mantle. They are supposed to have teeth in three series, and to feed on *Diatomaceæ*.

*Family DIPHYLLIDIADÆ.*

The Phyllidians are curious creatures intermediate between the Tectibranchs and the Nudibranchs. *Diphyllidia* has gills going round the back two thirds of the body, the plates being folded in front and behind at right angles to each other. The teeth and horny jaws resemble the Bubbles. There is a curious veil in front of the tiny tentacles, resembling a "respirator."

*Family PHYLLIDIADÆ.*

The *Phyllidias* have the general aspect of a *Cryptochiton*, the gills being arranged all round (except at the head) between the mantle and the foot. They have no jaws or tongues. The lips are small and conical; and the tentacles on the back can be drawn into pouches. *Fryeria* has a rough mantle, and the vent is under the mantle at the back. *Hypobranchicea* has the mantle extended into swimming flaps.

ORDER II. NUDIBRANCHIATA.

The Naked-gilled Crawlers form a large tribe of mollusks, of strange forms and marvelous beauty. They are found in all parts of the world, from the arctic to the torrid zones, wherever there is a firm, rocky bottom, or a crop of sea-weed. When first born, they dwell in a little nautiloid shell, with an operculum; and swim freely with a pair of pteropodal fins. Afterwards they drop fins, shell, and operculum, and become sedate Crawlers, breathing by means of exposed gills on the back, which assume various ornamental shapes, and can often be drawn into cavities of the mantle. In some tribes, the skin is coarse and leathery; while in others this and the various tissues of the body are so delicate and transparent that we may watch the beating of the heart and the digestive processes. The British species have been admirably examined by Alder and Hancock, and illustrated by the Ray Society in one of the most beautiful Memoirs ever published. It is probable that they are equally abundant in other parts of the world; but they have been very little observed. They are extremely timid; and when disturbed they draw themselves up into a mere lump of jelly or tough skin, so that ordinary collectors would pass them by altogether; and even experienced naturalists must live in their neigh-

borhood some time before he can dredge and examine the forms which belong to each fauna. As they do not preserve their shapes in alcohol, and leave nothing that can be kept in cabinets or impressed on stratified rocks, they can scarcely be understood without reference to figures; and therefore only the principal groups will be here described. The student is recommended to examine the plates of Alder and Hancock for the British, and of H. and A. Adams for the exotic tribes.

In the first group of families, the gills are on the back, near the tail, and surrounding the vent. The skin is leathery, of a spongy texture, and stiffened with minute darts.

#### *Family DORIDÆ. (Sea Lemons.)*

The *Doris* and its allies have tree-like gills, with the vent in the middle. The teeth are in very numerous longitudinal series, resembling the Bullas. They feed on zoophytes and sponges, and lay their eggs in a spiral ribbon, attached on one side. The body is convex; the mantle large, but plain at the sides; and the back tentacles can be drawn into pouches. The gills can be drawn into a general cavity. The genera *Glossodoris*, *Chromodoris*, *Actinodoris*, *Asteronotus*, *Actinocyclus*, *Atagema*, and *Dendrodoris* are characterized by differences in the shape of the gills, tentacles, and mantle. In *Hexabranchnus* and *Heptabranchnus*, each gill has a pouch to itself; the circle in the latter not being complete.

#### *Family ONCHIDORIDÆ.*

In *Onchidoris*, the gills are not retractile, and the back tentacles are laminated. The tongue is narrow, with two rows of large teeth (as in *Philine*) and buttresses outside. The other genera are *Acanthodoris* and *Villiersia*.

#### *Family GONIODORIDÆ.*

The *Goniodorids* have a flattened, angular body. The mantle does not reach the head and foot, and the gills are not retractile. The tongue-ribbon is narrow, with four series of spines. The Red Sea *Brachichlanis* has the tentacles in front of the mantle.

The lovely *Idalias* have the mantle almost obsolete, but produced into four false tentacles in front of the true ones, and smaller ones round the gills. In the very curious *Ancula*, (afterwards named "Miranda,") the mantle degenerates into a semi-circular palisade to protect the beautiful bunch of branching gills. The tentacles are elegantly folded at the ends, and below are fringed with spreading feelers. This smooth, transparent, slug-shaped creature, only yet known in the German ocean, glides along, with a spreading moustache above its mouth, carrying its living flower-basket on its back.

#### *Family POLYCERIDÆ.*

The "many-horned" Nudibranchs differ from the last family in having twelve or sixteen teeth on the tongue-ribbon. In *Polycera*,

the mantle makes a spiked fringe, surrounding the gills and tentacles. *Palio* has the veil slit in front. The tail of *Trevelyna* is lancet-shaped. In *Thecacera* the mantle is obsolete, and the tentacles retractile.

*Family* TRIOPIDÆ.

In this family the teeth are in very numerous rows, on a broad ribbon, but slightly hooked. The tentacles are retractile, within plaited sheaths. *Triopa* has a beautiful set of palisades between the mantle and the foot, forming a fan-shaped row of ornamented tentacles above the mouth. Other genera are *Euplocamus* and *Plocamoceros*. *Ægires* has the tentacles smooth, and the teeth uniform.

*Family* CERATOSOMIDÆ.

*Ceratosoma* has conical, spiny teeth in uniform rows, with a spiny, somewhat retractile snout. The gills are retractile into a projecting horn-shaped pouch; but not the tentacles.

In the following groups, the gills are scattered over the back of the animal.

*Family* TRITONIADÆ.

The *Tritonias* are elegant creatures, often large for the order, reaching six inches in length. The gills are arranged in ornamented plates, rising at regular intervals along the mantle-edge. The veil is large and fringed: the teeth in very numerous rows, behind the horny jaws; and the fringed tentacles retractile within the sheath. They live in shallow water, preying on zoophytes, &c.

In *Scyllæa*, the mantle-margin is produced into flaps, bearing the gills on their inner edge. The foot is narrow, and grooved for clasping floating sea-weeds, on which they are borne about.

*Family* TETHYADÆ.

The *Tethys* has an enormous flat veil, as large as the body, and copiously fringed at the edge. Although it has no teeth or jaws, fragments of crabs and shells have been found in its fleshy gizzard.

*Family* DENDRONOTIDÆ.

In the *Dendronotids* and the groups which follow, the stomach and liver are curiously spread out and branched. *Dendronotus* has a beautiful row of tree-like gills, along the middle of the back. The tongue-ribbon is broad, with very numerous series of serrated lancet teeth. *Bornella* and *Lomanotus* are other genera.

*Family* PROCTONOTIDÆ.

In *Proctonotus* and *Janus* the gills look like the stamens of a flower, copiously arranged round the mantle edge. There are strong horny jaws, and the tentacles are not sheathed.

*Family* DOTONIDÆ.

In this family, the tongue-ribbon is narrow, with a single series of recurved, serrated teeth. The gills are in two rows of shrub-like processes along the back, into which the liver-vessels enter. In *Hero*, *Gellina*, and *Nerea* the tentacles are not retractile; but in *Doto* and *Melibe*, they are slender, and can be drawn into the graceful sheaths which support them like a candlestick.

The *Chiorœra* of Puget Sound may perhaps belong to this group.

*Family* GLAUCIDÆ.

*Glaucus* is a very singular creature. The foot is rudimentary, and it swims in the open sea, feeding on Jelly Fish and *Verellas*. The gills are arranged on side-fins, spreading out like the snake-tails on a gorgon's head. The teeth have some resemblance to those of *Amoria* among the Volutes, but are serrated on each side of the point.

*Family* ÆOLIDÆ.

The *Æolis* tribe are very delicate, graceful, highly ornamented, and beautifully painted mollusks, which live in shallow water, principally preying on zoophytes. In confinement, they have been known to browse on the breathing ornaments of their fellows, or even to devour each other's bodies. The gills are arranged as very numerous stamens, in variously-grouped rows along the back. Into these enter the ramifications of the stomach and liver. The tentacles are generally simple and unadorned. The teeth consist of a single series of semicircular combs. The other generic forms are *Calma*, *Flabellina*, *Facellina*, *Coryphella*, *Favorinus*, *Phidiana*, *Cuthona*, *Cavolina*, *Galvina*, *Tergipes*, *Embletonia*, and *Calliopœa*. In the last genus the back-tentacles are obsolete. They are all characterized by having the last vessel of the liver stomach above the ovary, instead of below as in the previous families: but agree with the others in having only one orifice to the reproductive organs.

*Family* FIONIDÆ.

In this and the next family there are two openings for the reproductive organs, and two hind vessels for the liver-stomach. *Fiona* has four tentacles, jaws round the mouth, and a fringe on the inner side of each gill-stamen.

*Family* HERMÆIDÆ.

*Hermœa* and *Stiliger* have only two tentacles and no jaws. The little *Alderia*, from the salt marshes of Skibbereen, has no tentacles at all.

*Family* ELYSIADÆ.

In all the previous families, the gills have appeared the most beautiful and important organs of the Nudibranchs. In the rest, they are no longer seen. *Elysia* and *Placobranchus* breathe by means of *cilia*

or fine, soft hairs, spread over the surface of the body; and by plaits or vessels radiating on the back. Their bodies have long swimming flaps; and the branched liver-vessels open into the sides of the stomach.

*Family LIMAPONTIADÆ.*

In these lowest of Opisthobranchs, as in the lowest of the Heteropods, there are no special breathing organs. The aëration of the blood is carried on entirely through the skin. In general appearance, these creatures are like lungless Slugs. In *Limapontia* and *Actœonia*, the tentacles are crest-like; in *Ictis*, *Fucola*, and *Pelta*, they are linear. The little genus *Rhodope* is like a creeping worm, without mantle, shell, gill, tentacle, or any other appendage. It appears the most degraded of Crawlers, but no doubt enjoys life in its own way as it progresses over the sea-weeds of Messina.

SUB-CLASS HETEROPODA.

The Heteropods, or *Nucleobranchs* as they are sometimes called, are a very aberrant race of creatures; and, as such, placed in very different positions by naturalists. They are in fact Gasteropods, adapted for swimming in the open seas. As they do not crawl on the belly, they have scarcely a right to the name of the class: accordingly some authors treat them as an independent division, between the Gasteropods and the Pteropods. As however we have seen the crawling foot obsolete in the stationary *Magilus* and *Vermetus*; and scraggy, more fitted for leaping, in *Strombus* and *Phorus*; it is no great strain on our general idea of a Gasteropod to imagine its foot flattened into a fin for flapping in the open sea. Many of the Opisthobranchs have the foot developed into side-flaps for swimming: we have only now to imagine the boat propelled by one central scull instead of by a pair of oars. It appears the simplest arrangement to regard them as a group coördinate with the crawling Gasteropods, but inferior to them; as the implacental by the side of the ordinary Mammalia.

In some respects the *Nucleobranchs* are superior to the ordinary crawlers. Their bodies are more symmetrical and their locomotion more active. Dr. Gray, indeed, arranges *Ianthina* with *Scalaria* among the Proboscidifers, and the remaining groups with the Rostrifers. Nevertheless, the lower tribes are so like the lower tribes of *Nudiobranchs*—which indeed they all resemble in the exposure of their gills; and the whole group forms so natural a transition to the Pteropods, that this appears their most appropriate place. It will be understood, however, that Nature never arranges her creations in straight lines; but the higher animals in one division are commonly more complete in organization than the lower animals in the groups above it: each type producing the highest as well as the lowest within its own sphere.

The Heteropods have the sexes distinct, like the Comb-gilled Crawlers; and, like them, have the gills in advance of the heart. They resemble the Tectibranchs in the subordination of the shell; which sometimes envelopes the whole animal, sometimes only the vital organs,

and frequently is absent altogether. In the delicacy and transparency of their tissues, they resemble *Nudibranchs*.

*Family* IANTHINIDÆ. (*Violet Snails*.)

Among the aberrant Heteropods, the *Ianthinas* form an aberrant, not a typical family. The shell is very thin, snail-shaped, with a twisted pillar, angular at the bottom, and a slanting apex. The outer lip is always waved, affording a passage for the exposed gills. All the species are of a beautiful violet color, deepest on the under side, which is more exposed to the light when swimming. The animal has a pro-sobranchiate head, projecting beyond the mantle, ending in a stumpy snout, and armed with two long and two short tentacles. The latter may be regarded as eye-stalks without eyes. As the animals are believed to sleep by day and prey upon the Jelly Fish and Verellas by night, they have no need of them. But the most remarkable appendage is their float, consisting of air-bubbles set in jelly; which is about three times the length of the shell, and attached to the rudimentary foot. Below this the females fasten their eggs. Buoyed up by these bubbles, the ocean-snails float about in shoals in the open seas of warm climates, and are often cast on shore in vast numbers after storms. The teeth are in numerous series, like *Scalaria* and *Bulla*.

There is only one other genus in the family, *Recluzia*, in which the violet color disappears, and the shell somewhat resembles *Jeffreysia*.

*Family* MACGILLIVRAYIDÆ.

The little swimmers which compose this family have not only a normally-shaped shell, but also an operculum. As this is found in addition to the Ianthinoid float, it proves that the latter does not take its place in the last family, as had been supposed. The animal has a broad swimming fin, armed with an operculum bearing a support as in *Jeffreysia*. A breathing-pipe conveys water to the gills, which are covered in. There are two tentacles with eyes at their bases, and tongues armed with teeth and jaw-plates, as in the typical Pectinibranchs. The most remarkable feature however is the crown of four false tentacles, branching out behind the head like a collar, as in several of the Nudibranchs, and many times the length of the shell. The pretty little *Ethella* has the pillar of the shell pointed in front, and the operculum on an arm like the Strombs. It appears to be used as a shield; while the creature skips and jerks with its complex foot. There is a beautiful collar, composed of six elegantly fringed arms. *Gemella* has a foot like a square-toed shoe, with which it glides along the surface of the ocean. The shell is like a flattened *Recluzia*, with a few whirled operculum. "This shell-protected speck buoys up its tiny body" in the South Pacific, "cast abroad, though not lost, in the ocean's immensity." The singular little shells of *Calcarella* are abnormally spiral, looking more like those of the Pteropods. They are prettily fringed, like *Trichotropis*. The animals have comb-like gills; long, well-armed tongue-ribbons, and massive, armed jaws. They are crowned with eight fringed arms. All the creatures of this interesting and



little-known family are extremely minute. It is very probable that the animal of *Cheletropis* will be found closely allied.

*Family ATLANTIDÆ.*

The beautiful little glassy *Atlanta*, when first discovered, was supposed to be a recent *Ammonite*. It has a flat, keeled shell, very sharply keeled, and deeply notched like *Scissurella*. The broad, triangular swimming-fin has a little disc, with which it can moor itself to any floating object. The operculum begins as a right-handed spiral, but continues straight. The snout is very long; the eyes and tentacles large, and the neck thin. *Oxygyrus* has a cartilaginous shell, with a triangular, concentric operculum, like the supposed opercula of *Ammonites*. The teeth have a general similarity to those of *Carinaria*.

*Family BELLEROPHONTIDÆ.*

The *Bellerophons* are a singular race of ancient fossils, the true affinities of which are not yet agreed on. They are thin, globular, spiral shells; like a *Nautilus*, but without chambers, and displaying a keel or notch in the middle. Some liken them to *Argonauts*; others to *Bullas*; others consider them as enrolled *Emarginulas*; but the best-supported opinion is that they are as it were swollen *Atlants*. The little cretaceous species, without notch, are called *Bellerophina*. The palæozoic species with the whirls exposed are *Bucania*. Those with the whirls scarcely embracing, like an unchambered *Ammonite* with a slit mouth, are *Porcellia*. In *Cyrtolites* the whirls do not touch, and in *Ecculionophalus* they are drawn out like *Spirula*.

*Family FIROLIDÆ. (Glass-Argonauts.)*

It is no wonder that the shell of *Carinaria* has been taken for an Argonaut; and even that the true animal of the Argonaut was thought to be allied to this, which may be considered as the typical Heteropod. The front part of the gelatinous body is enormously developed, while the abdomen is small, and the tail (which takes the place of the opercular arm of the *Atlants*) is short and pointed. There is a long snout; with a short tongue, toothed as in the Strombs and Helmets. The eyes are hour-glass shaped, highly organized, and often furnished with a little eyelid. They float upside down, with their foot at the top, in the shape of a flat fin, armed with a small sucker for adhesion. Below, the principal viscera hang out from the back, and are protected by the glassy shell, the gills projecting beyond it. They come up to the surface to feed in the evenings, and are found in most warm seas. *Cardiapoda* has a discoidal shell, with flaps round the mouth. In *Firola*, there is no shell to protect the nucleus; and in *Firoloidea*, the gills are on the tail, and there is no sucker on the fin.

*Family PHYLLIROIDÆ.*

This family may be considered either as degraded Heteropods or Nudibranchs, forming an exact transition between the two. They

have no gills or fins; being simply a floating, gelatinous, slug-like body, with long tentacles but no eyes. In the union of sexes, the teeth, and the digestive organs, they resemble the Nudibranchs; in their habits and general appearance the Heteropods. They breathe all over the skin, like the lower species of *Firololidea*. The tail of *Phylliroë* is flattened into a fin; that of *Acura* is pointed.

*Family* PTEROSOMATIDÆ.

The curious little bit of jelly which composes this family may be compared to a thin *Acura*, with eyes instead of tentacles, but no snout; laid on the middle of a broad, floating flap. Its anatomy is not yet made out; but it forms a transition to the Pteropods.

## CLASS PTEROPODA.

(*Wing-footed Mollusks.*)

The "Sea-Butterflies," as they are sometimes called, are a race of creatures formed to live, permanently, swimming about in mid ocean. They are recognized at once by the two delicate fins, which are constantly moving, with considerable animation, when at the surface of the water. Most of them are crepuscular or nocturnal in their habits; spending the day, poised in the lower depths, and rising, at different periods and degrees of darkness, according to the species, to enjoy their active life. Some kinds, however, disport themselves beneath the mid-day tropical sun. In their first stage, they exactly resemble the fry of the Gasteropods; but the larval fins of the Pteropods fall off, like those of their neighbors, and the permanent fins are developed round the neck, answering perhaps to the neck-lappets of the *Turbos*, &c. They have no foot; but in some of the groups there is a little lobe between the fins, which is its commencement. Sometimes their feelers have a few minute suckers, by which they can hold their prey or moor themselves to floating objects; in which, and in the bending back of the alimentary canal along the abdomen, they resemble the Cephalopods. They are however inferior, in point of organization, to the Crawlers. They have a very feeble circulation and respiration; the nervous centres are behind the gullet; there are no eyes; the gills either do not exist or are near the tail; and the senses are rather diffused over the body than localized in special organs. In the reproductive system, and in many special points of structure, they closely resemble the Heteropods. In fact, it is probable that the whole class of Pteropods should be regarded simply as a subclass of Gasteropods, connected with the typical forms by *Carinaria* and *Ianthina*. Like the Heteropods and Opisthobranchs, some have shells and others none; but in this tribe, the shelly races are the lowest in rank, inasmuch as they have no heads: in this respect alone passing into the next great group of bivalves. They are, therefore, here arranged after the naked tribes.

The Pteropods are few in number, as far as species are concerned; but these are widely diffused, many of them being common to the Atlantic and Pacific oceans. But in individuals they are incredibly

numerous; their tiny, fragile, transparent forms being found in vast shoals, so filling the sea, that even in the Arctic regions the water is often discolored by them. They never willingly approach the shore, not having the muscular power of the Cephalopods to swim away from danger: but their delicate glassy shells line the sea bottom at enormous depths, and in many districts will form almost the only fossils by which future geologists will recognize the strata. The living forms of Pteropods are all very small, the largest scarcely reaching two inches in length. They first appear in the Eocene beds. There are, however, certain puzzling shells, found in the palæozoic rocks, which may have belonged to gigantic animals of the tribe.

#### ORDER I. GYMNOSOMATA. (*Naked Pteropods.*)

These creatures have no mantle or shell, and the gills are indistinct. They have however a respectable head, and a tongue-ribbon of numerous rows of hooked teeth, as in the Opisthobranchs. Like all the other Pteropods, they are carnivorous, preying on minute Crustaceans, Jelly Fish, or Infusoria.

##### *Family* PNEUMODERMONIDÆ.

The *Pneumodermons* have the body shaped something like a Cuttlefish, and highly colored. There are two tentacles, copiously fringed with tiny anther-like suckers. The gills are leaf-like projections at the tail. When touched, they fold their wings round their neck, roll themselves into a ball, and fall to the bottom. In *Spongiobranchia*, the gills form a spongy ring round the tail; and the tentacles have cup-shaped suckers, forming a close approach to those of the Cuttles. In *Trichocyclus*, there are no gills; but three rows of tiny hairs round the head, tail, and middle take their place.

##### *Family* CLIDÆ.

*Clio* was the name given by Linnæus to all the Pteropods then known. It is now restricted to rather slender animals which, small and delicate as they are, form the principal food of the mighty whale. The monstrous creature opens his enormous mouth; takes in a sea of water; filters out his *Clios* through the whalebone sieve; and ejects the water through his nose. The *Clios* have a number of small tentacular processes round the mouth, furnished with minute suckers. In swimming, it touches the ends of its fins on each side. In *Cliditia* the tentacles are obsolete. In *Pelagia* the head (to speak respectfully of this indistinct organ) is truncated in front.

##### *Family* CYMODOCEIDÆ.

*Cymodocea* differs from other Pteropods in having a second pair of club-shaped wings, behind the ordinary ones.

#### ORDER II. THECOSOMATA. (*Clothed Pteropods.*)

In these headless tribes, the body is generally shortened, and inclosed in a glassy, horny, or cartilaginous shell.

*Family* HYALÆIDÆ.

The *Hyalæas* are protected by a globular shell, consisting of a dorsal and ventral plate, (as in the Palliobranchs,) united at the tail. The two fins are retractile into the shell, and unite round the mouth. There are two tentacular processes behind, passing through side-slits in the shell, showing a resemblance to *Cymodocea*. In *Diacria* these processes are very small and inclosed, while the tail is produced. *Cleodora* has a glassy, pyramidal shell, of three flat sides, each ending in a spike. In *Balantium* the shell is funnel-shaped, not spiked. *Creseis* has a very slender, pointed, circular funnel. In *Cuvieria*, the shell is swollen at the base like an urn, generally with the point truncated. The point remains permanent in the *Vaginella* of the Bordeaux beds.

*Family* CONULARIADÆ.

The great carboniferous fossil *Conularia* was probably nearly related to *Cleodora* and *Creseis*, but as its relations are not clear, it is kept in a separate family. The shell is four-sided, and very beautifully striated across. In the Devonian form *Coleoprion*, the angles are rounded-off. The Silurian *Theca* has a shell like an elongated *Cleodora*, without spikes. *Pterotheca* has wing-like projections at the sides.

*Family* LIMACINIDÆ. (*Spiral Pteropods*.)

The tiny shells of *Spirialis* are spiral, with the point either raised or depressed. Between the fins is the rudiment of a foot bearing an operculum. These creatures furnish the nearest approach to the larval Gasteropods. In *Limacina* the mouth is round, and there is no operculum. The shells of this family may be known from the Macgillivrayids, by being always reversed.

*Family* CYMBULIADÆ. (*Glass-Slippers*.)

The lovely *Cymbulia* inhabits an elegantly-cut cartilaginous shell, foreshadowing the Argonaut, the wings flapping on each side, as the sails of that Cuttle were formerly supposed to act. The lingual teeth in this genus, and in *Eurybia*, (which has a cup-shaped boat, and tentacles,) are arranged in three series. *Eurybia* similarly foreshadows *Bursatella* among the Opisthobranchs. *Tiedemannia* is like a *Cymbulia* without the glass-slipper, forming a transition to the first order; while the delicate little *Psyche* seems no more than a minute, transparent globe, wafted over the banks of Newfoundland by its spreading wings. And so end the higher groups of Molluscous Animals.

## CLASS LAMELLIBRANCHIATA,

(or *Plate-gilled Bivalves*.)

The remaining classes of mollusks present us with a very different type of organization; inferior, indeed, to the head-bearing tribes, and

yet equally perfect after its kind. The student of vertebrated animals and of the various insect tribes, as well as of the Cephalopod and Gasteropod mollusks, naturally looks upon the head as the most important part of every living creature. We are now going to be introduced to animals in which not only the head becomes sometimes obsolete, as in the shell-cased Pteropods, but the whole plan of the organization makes the existence of a head useless, and therefore impossible. The special work appointed for the bivalve and cloaked mollusks in the economy of nature, is to filter the water at the sea bottom from its infusorial particles. They never *prey*, either upon living creatures or sea plants; hence eyes, jaws, snout, and curiously-armed tongue, which are the characteristics of ordinary mollusks, would be entirely useless. To go about looking for food, when the very air they breathe comes burdened with dainty meat, would be a waste of energies; so that a swimming or crawling foot is not a requisite of their life. Their special functions are to digest and breathe, in a quiet but uninterrupted manner. All the locomotion they require is to settle themselves in a snug place; and then they simply suck-in the water, and let it bring food to their mouth and air to their blood. When at rest, they are entirely encased in their shelly covering, like the *Turbo* and *Nerite*; but when in action, instead of crawling out of their shell, they open the shell itself to let in water. The shell is therefore made of two plates; which in the ordinary bivalves interlock by means of a toothed hinge, and are fastened together by a ligament.

The headless tribes of mollusks naturally divide themselves into three great divisions. In the clams, oysters, mussels, and cockles, the animal breathes by means of large plate-shaped gills; and the valves are, as it were, great wings on each side of the body. But in the lamp-shells, there are no gills, the breathing being performed by the skin, and by the action of very delicate hairs arranged on twisted feelers; and the shelly valves, instead of being side-wings, are shields on the front and back of the animal. In the third division, instead of a shell, the animal is wrapped up in a leathery coat. The ordinary bivalves are often called *Acephala* (Headless creatures;) a name which is equally applicable to all three divisions, and to part of the Pteropods. Their common name is *Conchifera* (Conch-bearers;) but as conchs are univalve shells, and as the name was given to include both the clams and the lamp-shells, it appears best to distinguish them by their leading characteristics as *Plate-gilled*, *Mantle-gilled*, *Cloaked* mollusks.

The oyster tribe lie on one side; and have neither foot nor breathing pipes. But ordinary bivalves do not lie as their shells are seen in cabinets. They stand upright, like a crawling Cuttle Fish. Their foot, or digger, is at the bottom; their nose and vent pipes close together at the top. At the back are the digestive organs: in front, a large water chamber, with the gills above, and the mouth below, behind the foot. The mantle enfolds the whole body, and secretes the two shelly plates. These assume an approach to a spiral form, from the growth being in front, the ligament remaining fixed. The breathing pipe is not a mere gutter, as in the predacious univalves, but a fleshy tube, armed with muscles to suck in the water, and often ele-

gantly fringed with feelers to aid the currents. As the water is sucked into the gill-chamber, the plates collect the minute plants and animals that float in it. These lie in their grooves, and are gradually formed into threads, which are carried down towards the mouth. Here they are laid hold of by a pair of long delicate flaps or lips, which draw the threads to the mouth. The filtered and carbonized water is forced back, along with the fœcal matter, through the excurrent pipe, which is generally longer than the other, in order not to interfere with the purity of the inhaled current. These mollusks generally live covered up with sand or mud; and might escape detection, but for the slight protrusion of their pipes; yet the disturbance they make in the water by their vigorous breathing is well known to all keepers of aquariums.

The bivalve shells are objects of great beauty, both as respects form, sculpture, and color. It is however unfortunate for geological purposes that the principal differences among them depend on the internal structure, the hinge teeth, the muscular impressions, and the marks of the siphon pipes, which cannot often be seen in fossil specimens. Dr. W. B. Carpenter has however shown, (*v. Reports of the British Association, 1844, pp. 1-24,*) that the structure of the shell affords very characteristic marks in several of the families and genera, by which the affinities of fossil specimens and even fragments may often be satisfactorily determined.

The bivalves do not group themselves into natural orders like the univalve mollusks. There is a much greater similarity of type among them, and the points of difference are not constant among the creatures whose general relationships correspond. If we compare a "clam" with an oyster, we see at once that the clam has two water pipes, a foot, and the mantle closed in front; while the oyster has an open mantle, without foot or pipes, and has only one muscle instead of two to work the valves. Yet if we separate according to any one of these characters, the division, will not suit others, and we shall be obliged to part closely allied groups. It may be best therefore to allow the families to follow each other in a natural order, without insisting on orderly or suborderly lines of demarcation. The following are however the leading types of structure:

I. *Borers, Razor-shells, Mya-clams, &c.*, in which there are two long water pipes, more or less united and retractile, the gills being produced into the breathing pipe, and the mantle closed except for the foot and pipes.

II. *Venus-clams, Tellens, Cockles, &c.*, in which the pipes are generally separate, the gills not produced, and the foot mostly flattened for crawling or leaping.

III. *Sea and Freshwater Mussels, &c.*, in which the mantle-lobes are only closed to form a breathing hole.

IV. *Oysters, Fan-shells and Arks*, in which the mantle-sides are entirely separate.

The *Venus* tribe may be considered as the typical and most highly-organized Lamellibranchs; from these the stream of affinities flows down through the Mussels and Oysters, towards the Palliobranchs; and through the Borers towards the Tunicaries. As however we can-

not speak or write in diverging lines, it is more convenient to begin with the borers, although they are in many ways abnormal.

Several of the Lamellibranchs are now known to have the sexes separate, like the trunk-bearing univalves. As the individuals always maintain a solitary existence, it is probable that the fecundating influences are diffused and inhaled through the breathing currents. The eggs are matured between the outer plates of the gills. The young always swim freely about, by means of a hairy flap, which disappears when the foot is developed, at the front of which is a slender tail. At this time they have minute eyes, which disappear as the animal hides itself within its wings. It is singular that in the last published treatise, these creatures are said to be self-impregnating hermaphrodites; although the difference of shape between the shells of male and female specimens has often raised them to the rank of different species.

It is evident from the essential conditions of life in these headless mollusks, that their structure could not be modified to exist on land, like the Pectinibranchiate and Pulmonic Snails. A very few of the plate-gilled families are able to exist in fresh waters; but the whole of the other classes are marine.

#### *Family PHOLADIDÆ. (Piddocks or Date-Fish.)*

If we divide the ordinary bivalves into active or sedentary, according to their habits of life, we shall find among the latter the two most widely divergent groups—the *oysters*, which sleep on their sides, and the *borers*, which stand on their feet. The habits of the borers have been already described at some length, (*v.* Smithsonian Report for 1859, pp. 209–217:) it will be sufficient here to point out the principal differences of structure. The Piddocks have white shells; generally very thin, but strong, and adorned with rasp-like sculpture. As this sculpture however is for the most part turned towards the aperture, it cannot be much used for excavating the hollows. The naturalist who took the trouble to bore a hole with the shell, could do so most easily if he turned the shell the wrong way in. As before stated, the stout club-shaped foot is probably the principal instrument of abrasion. This is fixed by strong muscles to the shell, which has no articulated hinge and ligament, like other bivalves, but is strengthened by a spoon-shaped process, curling up from within the beaks. The pipes are long, united till near the ends, and inclosed in a tough skin which is often protected by cartilaginous “cups.” The shells gape all round, except at a point before and behind, and the vacant spaces are generally covered, in the adult, by accessory plates; which caused Linnæus to separate them from their allies as being “multivalves.” They are phosphorescent, living by their own light; and are often eaten as a delicacy. *Pholas* proper has one shield placed behind the hinge. *Dactylina* has a shield over each valve, a cross piece, and a long plate along the back. *Zirphæa* has a broader shell without plates: it is the only one of the British species which is also found in America. The little group *Navea* are slightly modified to suit their residence in sponge. *Xylophaga* looks like a very short Ship-worm, making bur-

rows in floating wood, against the grain, about an inch long. The body is globular, with narrow pipes, separated at the end.

In the "Cup-pholas" tribe, the foot opening is large in the young shell, but closed in by shelly matter in the adult. There are however transition forms. *Pholadidea* has a single large cup in the adult, but no accessory plates. In the African *Talona*, there are two small cross-plates; and the foot-gape is very small, both in the young and adult. *Martesia* burrows in floating wood, and has the valves divided into two areas, like *Pholadidea*; it differs in having a large shield over the beaks, with another along the back; and in having no cup. One species has been found living in a Borneo river, twelve miles from the sea. The curious west American genus *Parapholas* has the valves divided into three areas, the third consisting of a tiled row of cup-plates. The adult is encased in large accessory plates, in front as well as behind. In this group the foot-gape in the adolescent animal is guarded by a strong deposit of shelly matter, to prop up and aid the foot. *Jouannetia* is like an exaggerated *Parapholas*, in which the callous plate of one valve overlaps the other, and the tile-cups are almost obsolete. As in the other members of this section, the pipe-ends are joined and surrounded by a common fringe, accounting for the roundness of the burrow-mouths. The Cup-pholads are found fossil in the secondary rocks; the ordinary forms in the tertiary strata.

#### Family TEREDIDÆ. (Ship-Worms.)

The Ship-worms are simply Pholads enormously lengthened; although at first sight the shape of their body would cause them to be regarded as Annelids or Vermetids, rather than bivalve mollusks. The common *Teredo* has a body from one to two and a half feet long; *i. e.* including the pipes; but the body, strictly so called, which contains the principal viscera, and is enclosed in a bivalve shell, open at each end like a pair of pincers, is not larger than a pea. The gills are long and extend into the tube, which is protected by a coat of shell outside. At the outer end, where the pipes divide, there are a pair of shelly flaps, which aid in working the inhalent and excurrent siphons. These flaps, which look like the "screw"-plates of a steamer, might be mistaken for the boring apparatus, but that they are always found at the opposite end from the boring foot. This is finger-shaped, as in *Gashochæna*; but it is quite equal to the task of wood-boring. There is no mollusk except the Ship-worm, which has excited the fears of merchants and statesmen. Not only ships, (if not coated with metal

or kyanized,) but piles and dock gates, have fallen victims to its ravages. Nevertheless it is a very serviceable creature, gradually destroying wrecks and other submerged wood, which might otherwise block up harbors and impede navigation. They are ovoviviparous and very prolific. They always bore *with* the grain, only turning aside to avoid knots or neighborly intrusion. In *Xylotrya* the breathing flaps are pen-shaped and jointed. Some of the species are found boring in the floating husks of coconuts.

There is a curious group of Sand-worms, as yet very little understood, but closely related to the Ship-worms. They encase themselves



in very thick shelly tubes, often a yard long and two inches across, of prismatic structure like the *Pinnas* and *Belemnites*. At the outer end, the pipe is divided across for a considerable distance. It is said that these *Septarias* have no bivalve shells at all; but that the foot-end is closed in by a cleft shelly plate.

The Ship-worms are connected with the ordinary borers of the fossil genus *Teredina*; in which the animal is as short as a stretched-out *Pholas*, enclosed in a thick tube, somewhat divided at the outer end. The valves, which were probably free in the young state, are soldered into the tube in the adult, so that the animal was completely encased. Fossil Ship-worms are found in fossil wood as far back as the Lias.

#### Family GASTROCHÆNIDÆ. (*Tube-Shells*.)

The valves of *Gastrochæna* have a true ligament, and move freely in their burrow, so that the little finger-like foot which protrudes from the otherwise closed mantle, is able to perform as much abrasion as the stout organ of the *Pholads*. When the *Gastrochæna* does not burrow in solid stone or shell, it forms an irregular club-shaped tube, in which it encloses both its pipes and its valves. In *Chæna*, which burrows in sand, the tube is straight; and the part which contains the rectangular valves is partitioned off from the pipe portion. The very curious shells of *Bryopa* are like a *Teredina* with one valve loose, and the other cemented into the tube. The animal is stumpy and irregular, with rather short fringed pipes, and has the general aspect of a tunicary in a shelly case. It is difficult to understand the use of the single loose, and the single fixed valve: Dr. Darwin might regard it as a *Gastrochæna* passing into a *Teredina*, or *vice versa*. The fossil genus *Clavagella* differs only in having the closed pedal end surrounded with a bunch of short tubes, in which respect it forms an interesting passage to the Watering-pots or *Aspergillum* group.

At first sight a "Watering-pot shell" would not be supposed to have any connection with ordinary bivalves. It consists of a tube, open at one end, at the other closed by a disk, full of holes, and generally surrounded by frills of shelly tubes. On looking attentively near the *rose* however, we shall see two irregularly imbedded valves, which are small in *Aspergillum* (the principal part being free inside) and large in *Penicillus*, and which show the intimate relation of the creature to *Clavagella*, *Chæna*, &c. In the middle of the *rose* is often a slight chink for the rudimentary foot. The open end, which appears above the sand, and is often adorned with one or more ruffles, affords an orifice for the breathing pipes. In *Foegia* the valves can scarcely be seen outside. The animal of *Humphreyia* attaches itself when young by the front edges of the valves, which it gradually extends into a tube.

#### Family SAXICAVIDÆ.

The *Saxicava* group are like shortened Gastrochænidæ, without any shelly tube. They sometimes bore, but more often nestle in holes made by other creatures, or in corners of rocks and roots, mooring themselves

by a lyssus, which they spin by their small grooved foot. It is said that five genera (placed in different families) and fifteen species have been made out of different conditions of the *Saxicava arctica*, which has spread itself over the northern hemisphere from the time of the middle tertiaries, having attained its greatest development in the drift period. The *Cyrtodaria* of Newfoundland is one of the coarsest of shells, covered with a horny skin, which in drying often cracks the shell inside. *Glycimeris* has a shell exactly like *Panopæa*; but the animal is a gigantic *Saxicavid*. The long pipes are united almost to their ends, the gills protruding into them; and the mantle-line in the shell is broken into joints. The shells gape all round like *Pholas*, but have a strong external ligament fixed to stout fulcrums.

*Family MYIDÆ. (Gapers.)*

In the *Myas* (called "Clams" in New England, and brought to market for food,) the shell is tolerably regular, and covered with a wrinkled skin which is produced over the pipes. These are united, and fringed at the end. The species are widely diffused, in time and space, and are generally pretty large. The cartilage is fixed in a pit between a projecting spoon-shaped tooth in the larger valve, and a hollow in the smaller. The Californian *Platyodon* has the pipe-ends strengthened by four shelly valves, reminding us of *Teredo*. The name *Mya* was given by Linnæus to all shells with an internal cartilage; but the character is not always constant in the same family. *Panopæa* (to which and to *Pholadomya* most of the fossils called "*Mya*" belong) has an external ligament, and small interlocking hinge-teeth, like *Glycimeris*. *Lutraria* has a shell resembling the New England "clam," but of more porcellanous texture; and with a spoon-shaped process in each valve to support the cartilage by the side of a tooth. Several shells generally associated with it by American authors have a *Mactroid* animal. The great Californian *Tresus*, which is eaten at Puget Sound, has small teeth on each side of the cartilage pit. *Seizocheilus* may prove to be identical with *Tresus*; it has two horny valves at the end to protect the pipes. The animal of *Eastonia* has not been examined; but the shell is like a heavy, swollen *Lutraria*, with radiating furrows outside.

*Family CORBULIDÆ. (Basket-Shells.)*

The *Corbula* group are like little *Myas*, but they scarcely gape, and have very short pipes, fringed at the ends. The foot is finger-like, adapted to poke in mud and sand, where they live often in immense profusion. They have one valve much smaller than the other; the hinge consisting of a conical tooth by the side of a cartilage pit in each valve. *Potamomya* includes the flattened estuary species; and *Corbulomya* some of the fossil forms, which begin to appear in the oolites. *Sphænia* has the nestling habits of *Saxicava*, with the front end of the shell very short. *Cryptomya* has a Myoid hinge, with a shell intermediate between that and *Sphænia*.

*Family ANATINIDÆ. (Lantern-Shells.)*

The shells in this family are almost always thin, pearly within, and roughened outside. They have an internal cartilage, supported on a spoon-shaped plate at the hinge, and strengthened by a shelly "ossicle" within. *Anatina* has the spoon supported by a clavicle at the umbos. The oolitic fossils, *Cercomya*, have the valves concentrically furrowed. In the nestling *Tyleria*, (of which only one specimen is known from Mazatlan, the clavicle is loose, twisted round the side of the shell, and united to it by numerous bridges. *Periploma* has a rectangular shaped body, without clavicle. *Lyonsia* has a shell of irregular growth, like *Saxicava*; and a very small spoon close to the umbo. Its Californian neighbor, *Mytilimeria*, lives imbedded in the nests of Tunicaries, and can scarcely open either its valves or its mantle. The beaks of the shell are spirally twisted, as in *Isocardia*. The shells of *Thracia* are not pearly, and are very rough outside. Some of the species are nestlers and distorted like *Lyonsia*.

The very beautiful shells of *Necera* are shaped like a *Corbula*, with produced beak to shelter the delicately fringed pipes. They are thin and pearly, and only found in deep water. *Theora* lives in shallower water, is more compressed, and has a very wide mantle-bend like the Tellens. *Thetis* has very short siphons, and a very long tubular foot; the hinge resembles the Kelliads.

Two singular groups are placed here provisionally, until the animals have been examined. The African *Tugonia* (also found fossil in the Pliocene) has a globular, twisted shell, somewhat resembling *Necera*, with a very large spoon-shaped cartilage-pit, and a very small mantle-bend. *Anatinella* is shaped somewhat like *Myodora*; with very long, narrow cartilage pits, and no bend in the mantle line. In this respect it resembles many of the *Corbulids*.

*Family PHOLADOMYIDÆ.*

There is only one living representative (from the West Indies) of a large tribe of puzzling fossils, which have received various names without much being known of their affinities. The living animal agrees with Anatinids in having only one gill on each side, but differs from all its predecessors in the mantle having a fourth opening in front. The ligament is external. The principal fossil forms which used to be classed under the general names of *Pholadomya* and *Amphidesma*, *Elnio*, &c., have been separated as *Homomya*, with thick shell and concentric sculpture; *Myacites* with *Goniomya*, *Tellinomya*, *Grammysia* and *Sedgewickia*; *Ceromya*, *Gresslya*, *Cardiomorpha* and *Edmondia*.

*Family MYOCHAMIDÆ.*

This is a small group of attached shells, representing as it were the oysters and *Chamas* among the Anatinids. The animals have strong points of resemblance with *Pholadomya*, having a minute ventral opening. The ligament is internal, and has an ossicle as in *Anatina*. *Myochama* lives on other shells at great depths, and has a small mantle-

bend. *Chamostrea* is shaped like *Chama*, attached on the anterior side, without sinus. They are all peculiar to the Australian region.

*Family PANDORIDÆ.*

The *Pandora* group are also nearly related to the Anatinids. The shell is shaped like the more regular of the *Lyonsias*, but flattened, especially on the right valve. The hinge is V-shaped, like *Placuna*, with an internal cartilage, but no ossicle. The valves are pearly within, and with minute prismatic cells outside, of which two hundred and fifty are about as large as one in *Pinna*. The mantle line is broken as in *Saxicava*, and scarcely bent, the pipes being very short, separate at the end and fringed. *Myodora* wants the V-shaped hinge, and has an ossicle. It is peculiar to the East Indies.

*Family SOLENIDÆ. (Razor-Shells.)*

We pass on to a very different-looking race of animals, though agreeing in many essential respects with those that have gone before. The Razor-Fish have the same habit as the *Myas*, *Panopæas*, &c., of burrowing in the sand; only they are created for more rapid movements. About two-thirds of the animal consists of the powerful foot, which can be pointed out, or made club-shaped, for the varied necessities of sand-boring, which it accomplishes with such rapidity that the creatures are difficult to catch, burying themselves to a great depth when disturbed. The pipes are very short, and not extended beyond the shell. This is like a piece of pipe cut across lengthways. The *Solen* may be taken as a good illustration of the ordinary habits of life of bivalves. It stands on its foot, like other animals; but this is the anterior or fore-end of the shell, the mouth and lips being behind it. The top of the animal is at the posterior or hinder-end of the shell; while the hinge is at the back, and the opening of the valves at the front of the creature, the shells being the side-wings. The length of the shell is from the anterior to the posterior ends, which represents the height of the animal. The breadth is from back to front of the animal; while the height, or thickness of the closed valves, really represents the breadth of the living creature. *Solen* proper has a straight shell, and one tooth in each valve; while *Ensatella* has a curved shell and 2-3 hinge teeth.

*Family SOLECURTIDÆ. (Short Razor-Fish.)*

The shells of this group are intermediate between the true *Solens* and the Tellens. The beaks, instead of being at the bottom end, are more or less near the middle, and the valves are generally flattened. The pipes are separate at the end, and more or less retractile. *Solecurtus* proper is like a Razor-shell cut short, while the animal is almost as long; the pipes being united into a stumpy tube till near the end. *Novaculina* contains the species which live in brackish water, and are covered with a coarse skin. The intermediate species have been called *Tagelus*. In *Cultellus*, the shell is flattened and the beaks are strengthened by a small slanting rib. The pipes are short and separate. *Ma-*

*chæra* has a stout rib coming out at right angles from the beaks. The mantle of the animal is beautifully fringed, and the pipes rather long. The animal of the European *Ceratisolen* is very similar; while the flat narrow shell is drawn out nearly to the length of a *Solen*. All the shells of this family gape, both at the foot and pipe ends; and their habits are like those of the Razor-fish. They do not make their appearance on our globe till the cretaceous age: the true *Solens* not till the tertiaries.

We now come to the typical Lamellibranchs, in which the pipes are narrow in proportion to the animal, not swollen to allow of the entrance of the gills. They are more or less united, or prolonged, in the various families and genera; passing from the Tellens in some of which they can be stretched out much longer than the shell, and widely divergent, to the cockles in which they are united together, and scarcely project beyond the valves.

#### *Family* TELLINIDÆ. (*Tellens*.)

The Tellens form a very beautiful and extensive family, abounding on all shores, where they live in sand or mud, generally at slight depths. The animals have very long, slender, and divergent pipes, and large triangular lips. The mantle is elegantly fringed, and open in front for the tongue-shaped foot. The shell is generally thin and transverse, often highly colored and very delicately sculptured.

In the first group, the shell gapes and forms a transition to the short *Solens*. The shells of *Soletellina* are generally violet, with a somewhat horny epidermis; having small hinge-teeth, and beaked at the breathing end. There is a strong ligament, supported on stout fulcrums. In *Sanguinolaria*, the shell is shortened and very thin. *Psammobia* gapes but little, and generally has the hinder side angular. In *Cap-sula* the shell is swollen, and ornamented with radiating ribs. This group makes its appearance in the cretaceous age.

The typical group *Tellina* consists of shells varying from a very transverse to a nearly rounded form, not gaping, and with a slight fold or angle at the breathing end. The muscular impressions are rounded and polished; and the mantle-bend is very large, occupying a large proportion of the shell. In the Californian species, *T. nasuta*, it is larger in one valve than in the other. The side teeth of the hinge appear to be of very little consequence in this group, being sometimes present in both valves, sometimes only in one, and often altogether absent. About two hundred species are now living, and nearly a hundred and fifty are found fossil, beginning with the oolites. The orbicular species have been called *Arcopagia*, a name also used unfortunately for a group allied to *Donax*. Some of the British, and probably of the American species are said to have only two, instead of four gills: they have been named *Macoma*. The *Strigilla* group, which abound in tropical America, have rounded shells with the valves obliquely sculptured. The elegant shells of *Tellidora* are found on the east and west coasts of tropical North America; they are white, flat, and triangular, like *Myodora*. The shells of *Gastrana* are some-

what wedge-shaped, with a bipid tooth in one valve. The animal is of sedentary habits, boring in mud or clay. The shell of *Elizia* is very like a flat *Diplodonta*, but there is a wide mantle-bend. *Lucinopsis* has a swollen thin shell, with a hinge like a *Venus*; but the animal is of the Tellen type.

The next group have the cartilage internal, like the *Mastras*; which appears at first sight a very great distinction, but there are some species that might be ranged with equal propriety in either section, the cartilage-pit being at the margin, close to the ligament, which is always external and generally slender. *Scrobicularia* lives buried in estuary mud, extending its pipes five or six times the length of the shell. The hinge-teeth are very small. *Semele* has a stronger shell, with a tooth on each side of the cartilage-pit. *Syndosmya* has a very thin, white, Tellinoid shell; with a hinge like *Scrobicularia*, but with lateral teeth. The animal of *Cumingia* is irregular, the shell being found nestling in crypts like *Saxicava*. One valve has very strong lateral teeth; the other none.

#### Family DONACIDÆ. (*Wedge-Shells*.)

The *Donax* family differ from the Tellens in having shorter breathing pipes, and stout, triangular shells. In the typical species of *Donax*, the breathing-end is very short, the foot-end long and pointed. The valves are stout, with crenulated margins and short ligament. There are strong lateral teeth. *Heterodonax* wants the crenulations, and has a rounded form. *Iphigenia* has a somewhat swollen shell, without lateral teeth. It lives in estuaries, and the species greatly resemble each other. The curious genus *Galatea* is peculiar to the African rivers. It has a very thick, triangular shell, with stout hinge-teeth like the *Venus* tribe.

Almost every sandy shore in the warmer regions has its species of *Donax*, which lives in myriads at a certain depth below the surface. At Panama, the natives clear off the sand just below this depth, and thus quickly collect bushels of the mollusks, which are considered dainty food. Yet the species, though more abundant than any other bivalves, are less widely distributed than most, each district having its peculiar form. They have not been found fossil previously to the tertiary ages. As among the Tellens, so here, a group is found with an internal cartilage. The marine *Erycina*\* has no little external resemblance to *Galatea*, being triangular and solid; but the cartilage is in a narrow pit between stout teeth. *Mesodesma*, which abounds in the Australian region, is shaped like *Psammobia*, but solid; with two short, stout lateral teeth. *Donacilla* has a wider distribution, and is wedge-shaped, with one of the lateral teeth long. *Ceronia*, one species of which inhabits the New England seas, has the side teeth strongly grooved. The Messrs. Adams unfortunately assign all the

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\*The genus *Erycina* is here restricted to the triangular shells of the *Mesodesma* type, called *Paphia* by modern authors. This latter name has a very obscure and intricate genealogy, and had better be dropped, as it is in use for butterflies. The heterogeneous genus *Erycina* of Lamarck has very properly been dismembered; but the name should be kept for the principal species.

species to California; although the west coast of North America has not yet furnished a single shell belonging to this sub-family. The shells of *Anapa* are shaped like *Erycina*, but there is no mantle-bend, and the animal may prove to be allied to *Crassatella*. The shells of *Ervillia* belong to the Atlantic ocean and the Red Sea. They have a Tellinoid shape, with deep mantle-bend, but no lateral teeth. Shells of this section have been found fossil in the earlier cretaceous age.

#### Family MACTRIDÆ.

The beautiful shells of this family are generally somewhat triangular, and with an internal cartilage, like *Erycina*: but the breathing-pipes are united to the end, and beautifully fringed. The mantle is freely opened in front, allowing free play to the tongue-shaped foot, which is used either for burrowing in sand or for leaping. The lips are very long and pointed. The shells are generally thin, and often highly colored. *Maetra* proper has well developed lateral teeth, double in one valve, and a small ligament separated from the cartilage. *Spisula* has the side teeth strong and cross-ribbed, as in *Ceronia*. The American genus *Mulinia* has the ligament internal as well as the cartilage; the side teeth smooth, and the mantle-bend angulated. In the African form *Schizodesma*, there is a triangular opening between the beaks to receive the ligament. *Mactrella* is a tropical American group; with very thin shells, keeled on one side and gaping at each end. The side teeth are very short, and the mantle-bend large and round. *Harvella* is another tropical American form, with paper-like shells, keeled on one side and concentrically furrowed. The ligament is separated from the cartilage. In *Standella* it is joined to the cartilage, as in *Spisula*, and the side teeth are short, not projecting beyond the cartilage pit.\* All the strictly marine Mactrids have a V-shaped hinge tooth, more or less developed. They are found fossil in all strata from the Lias. Another tropical American group, *Rangia*, (better known as *Gnathodon*,) inhabits brackish water, and has the breathing-pipes partly separated. Though the shell is angular, the hinge line is rounded, and the V-shaped tooth is broken into two. Though the shells are so abundant near New Orleans and Mobile as to be used for making roads, they are still sadly too rare in Europe.

Another somewhat aberrant group may, from the shells alone, be grouped either with the *Lutrarias* or *Maetras*. Their true position cannot yet be determined, through our ignorance of the animals. The *Raeta*, so abundant in South Carolina, but rare in Europe is like *Harvella*, with the side teeth changed into clavicles supporting the hinge plate. *Cypricia* (unfortunately confounded by Messrs. Adams with *Cryptodon* of Conrad) is a closely related form, not furrowed, and largely gaping in front. The mantle-bend in both groups is more akin to *Lutraria* than to *Maetra*. In *Heterocardia* it is very large, as in the *Tellens*, and the hinge somewhat resembles *Rangia*. The shells of *Cœcella* inhabit shallow muddy bays. They have a mantle-bend like *Maetra*, with a hinge like *Lutraria*. The very singular

\* This genus will probably be found more nearly related to *Lubraria*.

*Vanganella* has the shape and internal rib of *Machæra*, with a very projecting cartilage-pit, lying against the rib.

Family VENERIDÆ.

The *Venus*-tribe may be regarded as the types of the Lamellibranchs, presenting the greatest balance of characters. The animals have rather short pipes, fringed at the ends, and more or less united; the incumbent being the longer of the two, contrary to the usual habit. The mantle is closed in front, with a large opening for the tongue-shaped foot. They are found in all seas, generally in shallow water. They first appear in the oolitic strata, and are now at their maximum of development. The shells are strong, almost devoid of structure, very beautifully colored and sculptured, and held together by a stout, external ligament. The hinge teeth are very large, and generally divergent. As among the snails and other large families, there are so many intermediate forms between the extremes that the division into genera is a matter of great difficulty. The most elaborate classification of the species is to be found in Deshayes' British Museum Catalogue.

The shells of *Trigona* somewhat resemble *Erycina* and the Mactrids. They are triangular, with from three to six hinge teeth, and one rather long side tooth. The tertiary fossil *Gratelupia* greatly resembles it, with an additional number of small parallel posterior teeth. *Meroë* is wedge-shaped, with the margin crenulated, and the ligament in a deep-cut groove. *Cytherea* has a heavy shell, with a tooth next the ligament crenulated, and the outside tooth transverse. The mantle-bend is very slight. *Callista*, (which is the *Dione* of the British Museum Catalogue, and includes most of the species grouped together as *Cytherea* by Lamarck,) has a wide mantle-bend, the pipes being rather long, and united as in *Mactra*. The hinge teeth are 3-4, the outer being short, but transverse. *Dosinia* also has united siphons, with an angular mantle-bend. The shells are somewhat twisted spirally, with close concentric furrows, and a sharply-cut lunule. In *Cyclina*, the shell is thin, inflated, and without lunule, resembling *Lucinopsis*; but the animal closely resembles *Dosinia*. *Clementia* has a very thin shell, with a hinge resembling *Venus*, but pipes and mantle-bend like *Dosinia*.

The restricted genus *Venus* has the pipes separate and diverging; with a short angular mantle bend. The hinge-teeth are 3-3, nearly equal and spreading. The valve margins in this group are crenulated, corresponding with the fringing of the mantle. In *Chione*, (a bad name, because it does not include the old *Venus chione*, now a *Callista*,) the pipes are short and united at the base. The mantle-bend is very slight; and the teeth are 3-2, one being longer than the rest. The common *Mercenaria*, or "clam" of the Atlantic States, has the area inside the ligament coarsely furrowed. *Anomalocardia* has irregular, thick, triangular shells, with two teeth in each valve, and the mantle-bend almost obsolete. The little New England *Gemma* has the hinge of a *Venus*, the external aspect of a *Circe*, and the deep angular mantle-bend of a *Dosinia*.

The *Tapes* group have oblong, transverse shells; with narrow, com-



pressed hinge-teeth, often bifid. The animal has a long foot, grooved and often furnished with a lyssus. They are rather sedentary in their habits, hiding themselves in corners, and sometimes even burrowing in rock like the Saxicavids. The same species are however found on the same shores, either boring or free in the sand. The siphon-pipes are partly separate, and beautifully fringed; and the mantle-bend is deep. They most abound in the Old World. But on the northern shores of the Pacific is found a remarkable group, *Saxidomus*, with additional and somewhat irregular teeth, (as in *Trigona*), a posterior gape, and no lunule.

*Family* PETRICOLIDÆ. (*Boring-Venus Tribe*.)

These creatures have the mantle closed in front, like the Saxicavids, with an opening for the small, pointed foot: but the pipes are short and partially united, as in the Venus tribe. They generally bore in shells or rock; but the opening is irregular, and displays the "nose-end" of the shells. *Petricola* has a shape generally resembling *Gastrea*, with coarsely moulded beaks. The teeth are 2-2, often partially absorbed by the cartilage area, which in the *Choristodon* section is somewhat internal. *Rupellaria* is *Tapes*-shaped, and is an irregular nestler, like *Saxicava* and *Cumingia*: the valves are generally prettily cancellated. *Narario* has a rectangular shell, with divaricated sculpture outside, and bifid teeth within. All the shells in this family have a wide mantle-bend.

*Family* GLAUCOMYIDÆ. (*Solen-Venus Tribe*.)

The shells of *Glaucomya* are covered with a dark green skin, and are found in East Indian rivers, especially at the mouths. The hinge-teeth are small, as in the Tellens, and the shape is like a very transverse *Petricola*. There is a deep narrow mantle-bend, caused by the retraction of the very long, united pipes. The mantle is closed in front, except for the large mud-boring foot. The lips are large and sickle-shaped. *Tanysiphon* has long pipes, united nearly to the end.

In the remainder of the bivalves, (with a few abnormal exceptions,) there is no bend in the mantle-line, showing that the breathing pipes are not long and retractile. This however is not a character of ordinal importance. In the *Venus* tribe, we see the bend becoming smaller and smaller, till the passage from *Anomalocardia* to *Circe*, which has none, is scarcely sufficient for family distinction. In the following families, we sometimes find two perfect but short pipes, sometimes only one, sometimes a simple opening in the mantle. The mantle itself is either partially or wholly closed in front; or it is freely open for the passage of the water into the gill-cavity.

*Family* CYPRINIDÆ.

The shells of this group abound fossil from the secondary age, but very few are now living. The only living *Cyprina* has a shell like a swollen *Callista*, with a distant side tooth at the back. The little northern shell called *Circe minima* has an animal like *Cyprina*, with

very short siphons, and a mantle open in front. It has fewer hinge-teeth, and has been associated with *Gouldia*, which probably belongs, with the true *Circes*, to the Astartids.

*Family* ISOCARDIADÆ. (*Heart Cockles*.)

The animal of *Isocardia*, like that of *Cyprina*, has short pipes and open mantle. The shell is swollen, allowing of a very large gill-cavity; and the beaks spirally twisted, with the hinge-teeth following the curve of the margin. The foot is small, for sand burrowing. The fossil species are very numerous; but many called by this name belong to the *Pholadomya* group, and some to the *Arcas*. In the little group *Cardilia*, the ligament is fixed on an internal plate, as in some of the Lucinids.

*Family* CARDIADÆ. (*Cockles*.)

The Cockles abound in shallow water, in almost all sandy bays, and are extensively collected for food. On the northern shores of the Atlantic States, they are curiously rare; their place in the market being supplied by the clams. The animal has short pipes, covered with feelers; and open mantle, generally plaited at the margins. Most of the bulk of this mollusk consists of the foot, which is long and knee-shaped, doubled up into the gill-cavity when at rest, used as a leaping-pole when extended. The typical species of *Cardium* have swollen shells, with radiating ribs interlocking at the margins. The hinge teeth are small, but, with the side teeth, are deeply interlocking. The shells of *Bucardium* gape at the sides; those of *Levicardium* are smooth outside, but generally toothed at the margins; those of the boreal *Serripes* are almost edentulous. The cretaceous form *Protocardium* has the bulk of the shell concentrically furrowed, while the side has the usual radiating furrows. The *Hemicardium* group are keeled and flattened on one side; while the abnormal and very beautiful *Cardissa* group are flattened out on each side, with a hollow projecting keel. *Papyridea* is like a thin *Bucardium*, flattened in the opposite direction from *Cardissa*, and very much produced on one side.

The very aberrant Cockles of the Caspian Sea have very long pipes, not fringed, and united nearly to the ends. The foot is shaped as in *Venus*. The shells are shaped like common Cockles, but without teeth. Sometimes however there are one or two small ones. They are called *Adacna*, (with *Monodacna* and *Didacna*,) and are often arranged with the *Pholadomyas*.

Shells having a general resemblance to Cockles have been found fossil in all strata, beginning from the Upper Silurians. Several however must have had very different animals. The ancient group *Conocardium*, is like *Hemicardium* with a very long tube projecting from the truncated side, like the wing of an *Avicula*. The structure of the shell also is in cubical prisms; but the tube was probably for the protection of Adacnoid pipes, as in the *Gastrochaenids*.

*Family* ASTARTIDÆ.

The shells of this very extensive family partake of the characters of

the Venerids, the Cyprinids, and the Cockles. The animals however differ (so far as yet known) in having no true breathing pipes, but only a fringed opening in the mantle, as in the *Unios*. The foot is tongue-shaped, and the creatures are of sedentary habits, sometimes burrowing in coral. They form one of the most extensive groups of bivalves in the secondary and older tertiary strata; but now most of the forms are extinct, and others are dying out. It is probable that some of the following genera really belong to the Cyprinids.

The first division have shells furrowed like the Cockles. *Venericardia* also resembles that group in having a bent foot for leaping; but the shape and hinge more resemble *Venus*. *Cardita* has somewhat the shape of *Rupellaria*, and has a short lateral tooth within the ligament. *Thecalia* has a curious cup inside the valves to receive the eggs. *Trapezium* has 3-3 hinge teeth, besides the lateral. *Corallio-phaga* is shaped like *Lithophagus*, and is also a borer; but the hinge resembles Trapezium.

The oolitic fossil *Myoconcha* is shaped like *Modiola*, but was closely related to *Cardita*. It has a long tooth at the beaks, which is often encroached upon by the hinge-margin as in old specimens of *Cardita orbicularis*. *Hippopodium* (peculiar to the English Lias) has a very thick, irregular, toothless shell, looking like a gigantic *Saxicavid*. *Cardinia* and *Anthracosia* have *Unio*-shaped shells, abundant in the oolitic age, with a hinge more resembling the Cockles. *Pachyrisma* and *Opis* form a passage to the Heart-cockles. *Cypricardites*, *Pleurophorus*, *Megalodon*, *Goldfussia*, *Megaloma*, and *Pachydomus* are palæozoic forms, the relations of which are not yet properly ascertained.

The *Astarte* race are generally flattened shells with concentric sculpture. The fossil species abound in the oolites and tertiaries; the recent are few in number, covered with a thick, dull skin, and mostly from the boreal and north temperate zones. In the warmer seas are found small *Astartoid* shells with lateral teeth, called *Gouldia*. In the tropical regions of the east are found a group of shells with hinge resembling *Trigona*, but without mantle-bend. They are called *Circe*, and have a peculiar flattening at the beaks.

One group, related to the other members of this family in the animal, has the cartilage internal, as in *Semele* and *Mesodesma*. *Crassatella* has a ponderous shell with a stout hinge and short lateral teeth. It is found fossil from the cretaceous age. The shells of *Davila* are rounded and flattened, like *Felania*.

#### Family CHAMIDÆ.

The Chama-tribe seems to interrupt the natural sequence of the families, presenting us with a race of irregular shells like oysters, always attached, and generally covered with spines or ridges, like the *Spondyli*. The shells are known by the two strong muscular impressions, and the *Unio*-shaped teeth at the hinge. The umbos are more or less twisted into a spiral, as in the Heart-cockles. The animal appears to resemble a stationary *Isocardia*, with the mantle closed in front, and very short pipes. The foot is bent, as in the Cockles, but its use is not clear. They are found only in the warmer seas, begin-

ning from the green sand. They are generally attached on one side; but the Caribbæan *Arcinella* has the valves furrowed like a Cockle, and attached by the right beak. Fossil *Chamas* are found from the green sand upwards. One very singular group, *Diceras*, from the oolite, is like an exaggerated *Arcinella*. Both of the beaks are prominent and spiral, and the muscular impressions are bounded by shelly plates, as in *Cucullæa*. In the cretaceous *Monopleura*, the attached valve is funnel-shaped, and the other flat. Another cretaceous form, *Requienia*, has the left valve so developed spirally that it has the general appearance of a *Paludina*, the other valves looking like a spiral operculum.

#### Family HIPPURITIDÆ.

The *Rudistes*, as Lamarck called them, are characteristic of the cretaceous age, and are far more aberrant even than *Requienia*. As there are no living shells at all resembling them, and many of the forms are only known by casts, there has been a great difference of opinion as to their true relations. They were however probably related to the *Chama* group. In Woodward's Manual, pp. 279-289, will be found an elaborate explanation and figures of their chief peculiarities. They have a general resemblance to *Monopleura*, having one very long valve, with numerous partitions as the creature advanced upwards, Chamoid teeth, a strong internal cartilage, and tubes in the outer layer of the shell. The free valve is limpet-shaped. The *Hippurites cornu-vaccinum* is twisted like a cow's horn, and sometimes more than a foot in length. In *Radiolites*, the cavity for the animal is much larger in proportion, the internal mould having been called from its shape "*Birostrites*." *Biradiolites* has a very large ligamental groove. *Caprina* has a shape presenting an evident analogy to *Requienia*. One valve is twisted into a flat spiral, like an Ammonite, and is somewhat regularly chambered; the other valve being *Hipponyx*-shaped. *Caprinella* has the whirls separated, like *Criocerat*. They sometimes measure a yard across. *Caprotina* presents a more normally Chamoid appearance.

#### Family TRIDACNIDÆ. (True Clams.)

The American appropriation of the word "Clam" to the very dissimilar *Mya* and *Mercenaria* is somewhat perplexing, the name having been first given to the ponderous bivalves which inhabit the coral lagoons of the Pacific islands. They have a general resemblance to transverse Cockles, but differ from all other bivalves with closed mantles in having only one stout adductor muscle, like the oysters; the other being obsolete. The compact mantle has three openings; one in front, for the fresh water; one near the posterior side, armed with a tubular valve, for escape; and a very large one near the beaks, corresponding with a large gape in the shell for the finger-like foot, which is grooved to spin a stout byssus. A pair of valves of *Tridacna gigas*, measuring two feet across and weighing five hundred pounds, are used for holy water in the church of St. Sulpice in Paris. Such a mollusk may have been, when captured, more than a hundred years old. The

force with which they close the valves makes it dangerous to put the hand into the open shell. The Clam is considered good eating, and sometimes weighs twenty pounds. The beautiful *Hippopus maculatus* has no gape for the byssus: it is imported in vast numbers into Liverpool for parlor ornaments, where duly acidulated specimens can be procured at twelve cents each. These aberrant families make a digression from the main line of the Venus and Cockle group. We return now to the more normal forms.

#### Family LUCINIDÆ.

The shells of this family are either heart-shaped or flattened like *Dosinia*; but may generally be recognized by the great lengthening of the anterior muscular scar. The mantle is open in front, joined behind to form breathing passages. There is only one gill on each side, and the mouth and lips are very small. The foot is cylindrical and hollow, often twice as long as the animal. When at rest, it is doubled on itself, and hidden between the gills. Fossil forms are found even in the palæozoic rocks. *Lucina* proper has lateral and hinge teeth like the Cockles. Some specimens are obliquely sculptured like *Strigilla*, from which they are known by the mantle-line being without bend. *Codakia* has a hinge somewhat resembling *Dosinia*. *Loripes* has the ligament concealed and no lateral teeth. The animal has a long, fringed excurrent pipe. This is also found in *Cryptodon*, where the shell is thin and toothless.

*Fimbria* has a stout shell like a transverse Cockle, very beautifully cancellated. There are very few living species, but it abounds fossil from the Lias age. *Semicorbis* and *Sphæra* have no side teeth. *Unicardium* is almost toothless. The oolitic *Tancredia* is shaped like *Iphigenia*.

#### Family DIPLODONTIDÆ.

The shells in this family may generally be known by a bifid tooth at the hinge. The animals have two gills on each side, and a tubular foot. *Diplodonta* has a globular shell, and nestles in crevices. *Felania* a smooth, flat shell, living in sand. *Ungulina* has a very irregular ligament, and is said to bore. In *Scacchia*, the cartilage is internal, and the foot tongue-shaped. It forms a transition to the Kelliads. The shell of *Cyrenoida* resembles *Felania*, but the animal is figured with two united, rather long pipes, which however produce no bend in the mantel-line.

#### Family KELLIADÆ.

The Kelliads all have thin, small shells, generally with an internal cartilage. The animal has a strap-shaped foot, with which it crawls about, or moors itself by a byssus at pleasure. They generally nestle in holes and crypts, and have been mistaken for borers. Some species have a very wide distribution. They are found fossil in the tertiaries. In *Kellia*, the ligament interrupts the hinge margin, and the mantle is produced in front into a breathing tube. In *Lasea*, the ligament lies on the thickened hinge-margin. In *Turtonia*, it is external; and in *Cyamium* partly so.

*Montacuta* is destitute of the anterior tube, and the shell is slanting; the cartilage occupying a pit between two strong teeth. *Pythina* has the shell narrowed in the middle, generally with slanting sculpture.

*Family* LEPTONIDÆ.

This group differ from the Kelliads in having the mantle produced beyond the edge of the valves, and adorned with filaments. The foot is spread out, for crawling like a Gasteropod. *Lepton* has a shell somewhat resembling *Kellia*, often minutely punctured, with diverging teeth. *Tellimya* resembles *Montacuta* in shape, but has an ossicle in the cartilage-pit, like the Anatinids. *Galeomma* resembles an arc, with a wide gape in front. It has a small cartilage-pit, without teeth, and opens its valves wide, like *Solemya*. *Scintilla* has small hinge-teeth, and gapes at the sides. *Cycladella* perhaps belongs to the same group; but has lateral teeth, a hinge-tooth parallel to the margin, and an external ligament.

*Family* SOLEMYADÆ.

The little group called *Solemya* appears more related to *Galeomma* than to either *Solen* or *Mya*. The shell is extremely thin, enclosed in a wide horny skin. The hinge resembles *Leptom*, with a very long cartilage-pit. The creature opens its valves very wide, and swims by dilating the end of its wide foot, which it works as we open and shut an umbrella to shake off the wet. The mantle is closed in front; and there is a tail on each side of the excurrent opening. There is only one gill on each side.

We now proceed to the freshwater families; the first of which has relations both to the Kelliads and the Venus tribe.

*Family* CYRENIDÆ. (*Fresh-water Cockles.*)

These creatures hatch their eggs within the mantle, but are not very prolific. Their habits may easily be observed by placing the little creatures, which may be found in any pond or ditch, in a little fresh spring water. They then drag themselves along by extending their transparent tongue-shaped feet, and protrude their short pipes. The young shells are sufficiently transparent to allow of the gills and heart being seen within. *Cyrena* has two short, separate pipes, and a strong shell, with 3-3 hinge-teeth, and smooth laterals. It is found in the English tertiaries, but is now confined to tropical regions. *Corbicula* has furrowed valves, with grooved side teeth. The shells of *Batissa* have strong hinge-teeth, with very short laterals. They are from the Pacific islands. *Velorita* has a very stout hinge, somewhat resembling *Cyprina*, with a slight siphonal fold.

The temperate regions abound in the thin shells of *Cyclas*, which has two rather long pipes, partly united; and of *Pisidium*, in which the shell is slanting, and there is only one excurrent pipe. Both *Cyclas* and *Cyrena* are found fossil as far back as the Wealden rocks.

*Family* UNIONIDÆ. (*Fresh-water Mussels.*)

As far as shells are concerned, this family forms the special glory of

North America, and especially of the drainage area of the Mississippi. The American *Unios* are the most numerous, the most remarkable, and the most beautiful that are found in any portion of the globe. There is perhaps a special reason for this provision. In no other known portion of the earth is there so large an area covered with soluble limestone. The water of the rivers, being saturated with this, would be unfit for many of its uses, were it not for the immense development of this group of heavy shells. The North American *Unios* may be regarded as so many water-filters, absorbing the lime from the water, and preserving it from reabsorption by their strong horny skins. The musk-rats also play an important part in this economy, being nature's great *Unio*-fishers. They bring them up out of the streams, and leave the shells in heaps on the banks.

The *Unios* are too easily accessible to most of the readers of this report to need much description. They have the flaps of the mantle entirely separate, (except between the anal and branchial regions,) not united into breathing pipes; but in the breathing region the edges are fringed. The foot is large, thick, and tongue-shaped, enabling the animal to crawl for considerable distances in case of drought. They are often found half buried in sand or mud, leaving the beaks exposed, which thus become worn away by the acids in the water. But sometimes they lie on their sides like oysters; and at others they fix their narrow breathing end upwards. In Europe they are rarely found except in rather deep water; but in America even large and heavy species will be found barely covered by water, and stemming strong currents. To resist these, the shells of *Unio* have very stout hinge-teeth, with long interlocking side teeth, inside the strong ligament. But the *Margaritana* group, which abounds most in quieter regions, is destitute of the side teeth; and the *Anodons*, which are thin and toothless, inhabit the still and comparatively soft waters of the lakes and ponds. The extreme forms of the *Unionids* are widely removed from each other; but between each are so many intermediate shapes that their division into genera, however necessary for the easy identification of species, is a matter of great difficulty. Prof. Agassiz has however found that there are differences in the arrangement of the gills and other organs, which are more or less coördinate with those of the shells. It is very desirable therefore that all persons who have access to living specimens should examine and report on them on the spot; or at any rate preserve a number of each species in alcohol for future investigation. It was in this family that the bisexuality of the *Lamellibranchs* was first placed beyond dispute. The shapes of the males and females, especially in the "*U. perplexus*" group, are so very dissimilar that no persons unacquainted with the subject would be disposed to consider them the same species. This is due to the eggs in the female filling the whole extent of the outer gill; in some instances, as has been computed, to the number of six hundred thousand at once. The fossil species present the same generic forms as the recent, and are found as far back as the Wealden rocks.

Of the *Unio* group, with distinct lateral teeth, the following forms belong to North America: *Eurinea*, *Lampsilis*, *Canthyria*, *Thehiderma*, *Cunicula*, *Glebula*, *Uniomerus*, *Metaptera*, and *Plectomerus*; to South

America, *Corrugaria* and *Iridea*; to Africa, *Cœlatura*; to Asia, *Naia*, *Lanceolaria*, *Dipsas*, *Hyriopsis*, *Nodularia*; to Australia, *Hyridella*, *Parreysia*, and *Cucumaria*. The European *Mysca* has but slight peculiarities.

In the *Margaritana* group, without lateral teeth, the old pearl muscle, *M. margaritifera*, is found throughout the colder regions of both Old and New World. It used to be extensively fished in the British islands for the occasional pearls. *Complanaria*, *Alasmodonta*, *Leptodea*, and *Strophitus* are all found in North America; *Monocondylæa* and *Plagiodon* in South America; and *Monodontina* is an Asiatic form.

The *Anodons* of Europe, though very variable in form, are believed to belong to one species; but in North America the distinct forms are very numerous. The young of many Unionids are known to attach themselves by a byssus at pleasure; but in the South American *Byssodonta* this appears to be permanent. An accurate arrangement of the family, founded both on peculiarities in the animals and on geographical distribution, is still a great desideratum.

#### Family MYCETOPIDÆ.

In the South American *Mycetopus*, the mantle is open except around the anal aperture; the shell resembles a toothless *Solecurtus*; and the foot is very much lengthened, ending in a hammer-shaped knob.

#### Family IRIDINIDÆ.

The shells in this family closely resemble those of the Unionids; but the animals differ in having the mantle-flaps united at the side to form two short pipes. *Castalia* is like the Arciform Unios, with the hinge-teeth furrowed, as in *Corbicula*. *Hyria* has spreading wings like *Metaptera* or *Avicula*, with the teeth somewhat plaited. *Leila* can scarcely be distinguished from *Anodon* by the shell alone. These forms are peculiar to South America. In Africa are found *Pleidon*, with the hinge line broken across into numerous teeth, like *Arca*; *Calliscapha*, with slight crenulations on the hinge line; *Spatha*, with a bent hinge, like *Alasmodonta*; and *Iridina*, like a very transverse *Anodon*. There are no members of this family known from the northern continents.

#### Family ETHERIADÆ. (*Fresh-water Oysters.*)

Just as the *Chamas* might be regarded as Cockles turning into oysters, the Etherids may be considered as *Anodons* making even a greater stride in the same direction. The shells of *Etheria*, which were first discovered by Bruce, being eaten in the Upper Nile, are free when young, and shaped like *Anodon*; they have then probably a foot. But when adult, they are attached and irregular, resembling an olive-green oyster with two muscular scars. There is then no foot, and the mantle is freely open. It is found in the tropical rivers of Africa and South America.

Still more remarkable is the *Mulleria* from New Granada. It begins life, free, like the *Etheria*, with two adductor muscles; but when adult



and fixed, it is found to have left both the early free valves, having fastened them on the right valve, and deposited layer upon layer over them. At the same time the adductor muscles have united so as to form only one scar. Lamarck made his primary division of the bivalves into those with two and those with one adductor muscle. This creature would have had to march from one to the other order, as he approached maturity. The entire withdrawal of the animal from one valve and manufacture of another is a complete anomaly. It is greatly to be desired that some New Granadian would watch the development of the animal.

*Family MYTILIDÆ. (Mussels.)*

The Mussels are easily recognized by their triangular shells, which are generally pointed at the anterior, and very much produced at the posterior side. The *Mytilus edulis* is much used for food in some parts of England, and is found widely diffused in the northern hemisphere, being taken on both sides of the Atlantic and the Californian coast. About 400,000 are eaten every year in Edinburgh alone, and enormous multitudes are collected for bait. In *Mytilus* the mantle is freely open, fringed in the breathing region like *Unio*; and the small foot is grooved to spin a stout byssus by which the animals attach themselves to rocks or to each other in enormous numbers. The shell of *Myrina* resembles *Alasmodon*, and was found on floating blubber.

The shell of *Modiola* is swollen near the hinge; and the mantle is partially closed into an excurrent tube. The animal spins a very fine byssus, in which it sometimes wraps itself up. *Crenella* has a swollen transverse shell, always furrowed outside and crenated within. The hind part of the mantle is produced into an excurrent tube, and it is partially closed in front. The animal spins for itself a silky nest, or burrows in the test of *Ascidians*. The shells of *Lithophagus* are finger shaped and very thin. They burrow in rocks, shells, and corals, the hole being only just large enough to receive them and not to turn round in. The outside end is generally encrusted with spongy layers, of different arrangement in different species, often produced into long beaks, but always outside the skin, and capable of being separated from the rest of the shell. These beaks sometimes interlock; but have no more to do with the burrowing than the pallets of the shipworms.

Fossil Mussels are found in all ages from the palæozoic times. Those from the old rocks have been grouped under *Modiolopsis* and *Ortho-notus*.

*Family DREISSINIDÆ. (Closed Mussels.)*

These differ from the true Mussels, as *Iridina* does from *Anodon*. In the fresh-water *Dreissina*, which was accidentally brought on timber from Russia to London, and is now completely naturalized all over England, the mantle is closed all round, and produced into two short breathing pipes, with an opening for the byssus-spinning foot. The shell differs from the true Mussels in having a deck at the beak to support the anterior adductor muscle. The same deck is seen in the marine *Septifer*, and in the fossil genera, *Hoplomytilus* and *Myalina*.

*Modiolarca* has a thin shell moored to floating sea-weed, and greatly resembles *Modiolopsis* in shape. This also has the mantle-flaps united.

*Leiosolenus* represents *Lithophagus* in this family, from which the shell alone cannot be distinguished. It has however siphon pipes, and excavates a deep and very spacious burrow, like *Gastrochaena*.

The next group of families differ in the same way, as to the possession or absence of siphon pipes. They agree in having the foot large, bent, and deeply grooved; and in having numerous teeth at the hinge.

#### Family ARCADÆ. (*Arks*.)

The boat-shaped Arks are easily known by their distant umbos, with straight hinge and two well-marked muscular impressions. The mantle is freely open, without pipes, and the mouth is not provided with lips. The hinge may be regarded as having two diverging teeth, each of which is cut across into numerous smaller ones. In old specimens these are often obsolete, and a ridge appears instead. In *Arca* proper, the shell is cockle-shaped, and lives freely in sand or mud, crawling on its crenated foot. In *Scapharca*, which abounds on the shores of the southern States, the valves are unequal, and generally thin. The American genus *Noëtia* is like an ark with one side cut off. *Argina*, also an American form, is more regular; but with one row of hinge teeth very short and twisted. In *Lunarca*, which closely resembles it in form, the short tooth is not serrated. *Trisis* has the valves shaped like *Bysoarca*, but curiously twisted. It has some resemblance to the curious little fresh-water Ark, *Scaphula*, from the East Indian rivers, in which however the teeth are rather transverse at the ends, forming a transition to *Cucullæa*. In this group the serrations of the teeth are normal in the middle, but parallel to the hinge line at the ends. The posterior muscular scar is bounded by a stout ridge. This form is now almost extinct, but in the oolitic and cretaceous strata it was very abundant. In the *Macrodon* group of the older rocks, only the shorter hinge tooth is serrated, the longer one remaining as in *Unio*.

One large group of Arks is completely sedentary in its habits, remaining fixed in crevices or old burrows. But instead of spinning a byssus like the Mussels and Pinnas, it adheres by the end of its foot, which deposits a number of horny plates, which can be cast off and renewed on special occasions. It appears more convenient to regard Cockle-arks (*A. grandis*, &c.) as the types of the family, and to call the fixed species *Bysoarca*. The typical forms have long straight hinges, winged on each side; with very numerous sharp teeth, and a gape in front where the creature fastens itself, with its face to the corner like a naughty boy. In the common form *Barbatia*, the wings are rounded off, the gape is not seen, and the hinge line is slightly curved, forming a transition to *Pectunculus*.

Fossil Arks are found in great numbers in every age, the palæozoic forms being chiefly of the *Cucullæa*, *Cucullella*, and *Isoarca* type. They live now at all depths, from low water to two hundred and thirty fathoms; and in all climates, from the equator to Prince Regent

Inlet. The form of the ligamental area is an important guide in the discrimination of species.

Another very abundant group resembles a flattened Cockle, with the beaks nearly close and the hinge-line curved. *Pectunculus* has a ligament like *Barbatia*, with very strongly marked muscular scars. The inner margin of the valves is crennated, as in the Fan-shells, and the free borders of the mantle have rudimentary eyelets to correspond. The lips are simply a prolongation of the gills; and the foot is large and crescent-shaped, waved on the sole. They are probably more active than the Arks. Half the species known are from the American shores, where they range from shallow water to a hundred fathoms. They first appear in the Neocomian age. The oldest shells of this group, being found from the Bath Oolite, have the ligament concentrated in a pit between the beaks, like *Lima*, and are thence called *Limopsis*. A few species are still living in the Old World, from Norway to the Cape. As *Macrodon* and *Lunarca* are to the Arks, so is the little crag fossil *Nucinella* to *Pectunculus*. On one side of the hinge the teeth are broken up, while on the other the plain ridge remains. A very similar shell has just been found living at Cape St. Lucas, by Mr. Xantus.

#### Family NUCULIDÆ. (*Nut-Shells*.)

The shells of *Nucula* are like a small, angular *Pectunculus*, with a pearly layer within. The cartilage is in an internal pit, and the hinge is in two divergent rows of very sharply interlocking teeth. They are generally covered with a smooth, horny skin, while that of the Arks is shaggy, and of *Pectunculus* velvety. The foot is very large, deeply grooved; spreading out to crawl into a broad disk with saw-like edges. The mantle flaps are freely open, without pipes; and the plume-like gills are small, and united behind. The lips are very long, curiously ornamented, and capable of protrusion outside of the valves, forming a singular contrast to the Arks, with which they are generally associated. The *Nuculas* are found in deep water and in all seas; they date from the earliest rocks, and are very numerous in species. *Nuculina*, from the French Eocenes, resembles *Nucinella*, but with an internal ligament; while *Stalagmium* and *Nucunella* form transitions to *Limopsis*.

#### Family LEDIDÆ. (*Beaked Nut-Shells*.)

This family, in most respects closely resembling the Nut-shells, and like them having the mantle freely open, presents us with the strange anomaly of a pair of regularly formed siphon pipes, reminding one of *Pandora* and the Anatinids. The shell of *Leda* is like a beaked *Nucula*, with a slight mantle-bend. The pipes are unequal and partially united; there being two flaps from the mantle which fold together like a third tube. The species are found in deep water from all seas, and abound in most ages from early times. *Yoldia*, which is almost entirely a boreal form, has the pipes united, with a deep mantle-bend, but no flaps. The shells are less pointed, and are found fossil in the newer tertiaries. A group of very transverse shells, with the hinge

lines almost straight, and gaping at each end, are called *Adrana*, and found in tropical seas. The animal of *Yoldia* is very active, and leaps very far on its bent foot. The group *Portlandia* has an irregularly swollen shell, truncated at the side. *Neilo* has a similarly-shaped shell, but not nacreous, and with the cartilage external. The mantle-edge is double, and furnished with flaps. It is found living in New Zealand, but fossil in Patagonia. *Solenella* is a similar shell from Chili, but shaped like *Sanguinolaria*, nacreous within, and with part of the anterior tooth remaining undivided, as in *Macrodon* and *Nucinnella*.

#### *Family* TRIGONIAE.

The *Trigonia* race make their appearance in the secondary rocks, and abound as far as the cretaceous age; but in the tertiary series they have not yet been found. They linger however along with other old forms, in the Australian seas, presenting us with shells and animals of surpassing beauty. They have long, sharply-bent, pointed feet, like the Cockles, with which they can take surprising leaps. But they resemble the Arks in having the mantle freely open, the foot-sole crenulated, and the gills united. They are almost entirely nacreous within, and strongly sculptured outside. The hinge has 2-1 very large, deeply furrowed teeth. In many strata, the shell has entirely perished, leaving very characteristic internal casts, called "horse-heads" by the quarry men of the Portland oolite. *Myophoria* has a similar shell, but less sculptured. *Ascinus* makes its appearance in the Upper Silurian, with small, smooth teeth. Similar shells have been described as *Mactra*, *Isocardia*, *Anodontopsis*, *Anatina* and *Dolabra*. *Lyrodesma* is the earliest form in this family, with several radiating teeth, striated across. *Verticordia* is a small group from the newer tertiaries, and still living; with thin, nacreous, *Lucina*-shaped shells, with two Unioid teeth in each valve. The Eocene *Hippagus* has a similar shell without teeth. This family combines many of the characters of *Nucula*, *Castalia*, and *Cardium*.

#### *Family* AVICULIDÆ. (*Wing-Shells, Pearl and Hammer Oysters.*)

This extensive family of living and extinct forms are remarkable for the microscopic structure of the shells, as shown by Dr. W. B. Carpenter, (in the British Association Reports, before quoted.) The outside portion consists of large prisms; which in transparent young shells can be detected with a single glass, and in the old decaying shells of *Pinna* easily break up into needle-like fragments, resembling Arragonite. These have been formed by rows of simple shells, sometimes of different colors, piled one over the other. The fragments of the great *Inocerami* from the cretaceous rocks have the aspect of fossil wood. The same structure is found in the floats of *Belemnites*. The inside of the valves consists of true pearls, the beautiful iridescence of which is caused by very finely wrinkled skins, with layers of shell between. After the shell has been dissolved in acid, and the wrinkles flattened out, the iridescence ceases. Many of the fossil forms have shells intermediate in form between *Avicula* and *Pecten*; but their

family relationships can always be determined by the microscopic examination of any small fragment; the prismatic structure not being seen in the Fan-shells.

The animal of the Pearl-oysters has the mantle free all round, except where the flaps are joined, in the middle, by the attachment of the gills. The edges are beautifully fringed. The lips are plain, and rather small. There is only one principal adductor muscle in this and the remaining families of the Pectinibranchs; although there are often seen other small scars, formed by the foot-muscles and the retractors of the mantle. The foot is finger-like and grooved, working through a notch at the side of the shell, and spinning a byssus, which in *Pinna* is long and silky, but in other genera is horny and rather solid.

All the Aviculids which have been observed in the young state have the pointed shape of the Mussels, which is permanent in the *Pinnas*. These creatures, which are sometimes two feet long, stick their pointed beaks in the sand or mud, with the knife-like edges of their gaping shells projecting upwards. These are sometimes dangerous to navigation. They differ from the ordinary Wing-Shells in having the small anterior adductor somewhat developed. A little crab (called "Pinna-guardian" by Aristotle; perhaps the mollusk calls it Pinna-plague) is fond of nestling in its breathing cavity. Fossil species are found from the Devonian age; some of the thick oolitic forms being grouped as *Trichites*.

The typical *Avicula* tribe have thin, slanting shells, swollen in the middle, and produced on each side of the hinge into wings which are some times very long, but greatly vary in the same species. They are fond of mooring themselves to *Gorgonias*, floating wood, and other light bodies. One valve is generally larger than the other; and there are small hinge-teeth as in *Alasmodon*. The fossil species are very numerous, beginning from the earliest rocks.

The Pearl-oysters, (*Margaritiphora*,) have heavy shells with short wings, having thick layers of "mother o'pearl," beautiful wherever it is worked. The pearls themselves are formed by excrescences or deposits of pearly matter in the mantle, often taking form from sand or other extraneous substance which has been introduced. Nearly three hundred tons of this shell are yearly imported into England. They have no hinge teeth. In this respect they resemble the Hammer-oysters, (*Malleus*,) which take the contrary extreme of shape. The body and the side-wings being all very long and narrow, the shell takes the form of a T. In the young shells, which are often regarded as distinct species, the side wings are not developed. The shape then resembles the *Vulsella*, which lives embedded in sponge, and has the ligament concentrated in a spoon-shaped cavity. Some of the early fossil forms have been grouped as *Ambonychia*, *Cardiola*, and *Eurydesma*. *Monotis* and *Halobia* are from the Triassic rocks. The Silurian *Pterinea* and the oolitic *Pteroperna* have few or numerous anterior teeth, and long posterior teeth as in *Unio*. The ancient *Posidonomya* has a thin, earless shell, without teeth.

In the remaining group of this family, the young shell is like *Avicula*, but in the adult the ligament is fixed into numerous pits along the hinge line. The name *Perna*, given by Lamarck to the common

forms, with square pits, has been used by different authors in such various ways that it may be convenient to revive the old name *Isognomon*, (or *Melina*.) In some of the tertiary fossils, the pearly layer is an inch thick. *Crenatula* has the pits small and rounded. In the fossil *Gervillia* and *Bakewellia*, which abound in the secondary strata, there are long hinge teeth inside the ligament row. *Inoceramus*, which is very characteristic of the cretaceous age, has the shell and the hinge rounded. Some species are a yard long. Other fossil forms are *Hypotrema*, *Catillus*, *Pulvinites*, and possibly *Pachymya*.

*Family PECTENIDÆ. (Fan-Shells, or Scallops.)*

The Fan-shells are at once recognized by the broad ears on each side of the beaks, with a slit in one valve for the passage of the foot and byssus. The animals have a double edge to the free mantle; the inner hanging like a fringed curtain, the outer bordered with a row of minute eyelets, each of which is protected by filaments. The gills are extremely delicate, and hang loose. The lips are beautifully cut. The shell consists almost entirely of membranous plates laid over each other. In the young state all the species moor themselves by a lyssus, which some do permanently. Others live freely, either few together, or in great scallop banks. They can swim by flapping their valves, often jerking themselves some yards at once. They do not abound on the west coast of the Atlantic; but in most seas they are numerous, and generally very highly sculptured and painted; the lower valve often having a very different hue from the other. Mollusk-eaters consider them great delicacies. The cartilage is in an internal pit. The typical *Pecten*s have the valves nearly equal. In *Amusium* one is generally larger than the other; the shell gapes at the sides; and the valves are either smooth or irregularly waved. In *Janira*, which includes some of the finest species of the tribe, one valve is flat or even concave, while the other bulges. The *J. jacobæ* of the Mediterranean was formerly worn by pilgrims who had been to the Holy Land. *Pallium* differs from the ordinary Scallops in having teeth on each side of the hinge-plate. *Neithea* differs from *Janira* in the same way. *Hemipecten* has only one ear; the other being incorporated into the shell. Fossil species are plentiful in all ages from the carboniferous. Those of *Aucella* and *Aviculopecten* form the transition to the Aviculids.

*Family LIMIDÆ.*

The *Lima* group differ from the true *Pecten*s in having no eyelets on the outer mantle-margin, and in having the inner fringed with very long and numerous tentacles. The shells are always white; and the inner layer is pierced with a network of minute tubes. The ligament is in an external pit, like *Vulsella*, and the ears are very small. The creatures can swim by jerking their valves, like the *Pecten*s. They either live free, or moor themselves by a byssus; or make a nest of stones and broken shells, spun together by byssal threads, in which they completely hide themselves. Fossil species are extremely numerous, from the carboniferous age; and abound in the Lias and oolites,

where they are often of large size, and are called *Plagiostoma*. *Limæa* begins with the Lias, and has one recent representative. It is a *Lima* with a row of Arca-like hinge teeth. *Limatula*, a northern group which begins in the English Crag, has the valves equilateral.

*Family SPONDYLIDÆ. (Thorn-Oysters.)*

These creatures may be regarded as attached Fan-shells; and form a natural transition from them to the true Oysters. The animal of *Spondylus* closely resembles that of *Pecten*, but the foot is rather more rudimentary, and there are no eyelets. The shell has strong interlocking teeth, and the attached valve has a very long beak, with a flat area, which is wanting in *Plicatula*. In one specimen of the "Water-clam" (so called from the layers of shell having spaces between them) in the Smithsonian Museum, there is an area in both valves. Fossil species are found from the lower oolites. The *Spondylus spinosus*, a very characteristic species of the chalk, lived nearly free; like the recent *S. imperialis*. *Hinnites* begins free like a *Pecten*, and afterwards becomes fixed. *Pedum* has a thin, flat shell; living imbedded in madrepores. It has a deep notch for a byssus in the lower valve.

*Family OSTREIDÆ. (Oysters.)*

As all readers of this report have access to Oysters, which, instead of eating, they can dissect and examine at pleasure, it is needless to describe either the shell or the animal. The chief peculiarity is the entire absence of foot. They are found in all seas, and in every age from the carboniferous; varying greatly in form, according to the surface to which they have been attached. The mangrove-oysters (*Dendrostrea*) are thin and but slightly attached. The cock's-comb species are deeply plicated. In the fossil genus *Gryphæa* one valve is spirally twisted, and the other nearly flat. The animal was probably not attached. The shell of *Exogyra*, characteristic of the oolitic and cretaceous ages, is *Chama*-shaped. The fossil *Ostrea longirostris* of the Tagus is sometimes two feet long.

*Family PLACUNIDÆ. (Window-Shells.)*

The Placunids are extremely flat, thin creatures, with a very unusual hinge. There are two long divergent teeth, like a V, to the sides of which the ligament is attached, as in *Pandora*, to which the shell offers some resemblances. It consists of very thin, somewhat nacreous plates. The shells of *Placuna*, often called Saddle-oysters from their shape, have the hinge-ridges equal, and rapidly diverging. Those of *Placenta* are nearly transparent, being used for window glass by the Chinese; and have the hinge ridges nearer, and one shorter than the other. *Placunopsis* is an oolitic fossil, with a transverse ligament groove. There is only one principal muscular impression in the Placunids.

*Family ANOMIADÆ.*

The shells of this family are remarkable for the large number of

muscular impressions in the convex valve. The flat valve is pierced by a hole, which is filled up by a shelly plug, which is more or less separate from the valve. The animal differs from the Oysters in having a small foot, connected with the plug which takes the place of the byssus in the mussels. The convex valve has four scars, of which the largest is made by the plug muscle, and the front one by the adductor. The third central scar, and one near the internal cartilage, are made by the retractors of the foot. The *Anomias* are extremely thin and pearly, found in all parts of the world, and in all ages from the oolites. In *Placunomanomia*, there are only two instead of three muscular scars. The hinge fulcrum is notched, and the plug often becomes imbedded in the lower valve. The fossil *Limanomia* is eared like *Lima*. *Carolia* has a plug when young, like *Anomia*; but when adult it resembles *Placunopsis*, and might be ranked with either family. It belongs to the tertiary age.

The species in this family ought always to be studied in connection with their geographical relationships; and the young animals ought especially to be examined, as being less likely to be affected by the disturbing influences of later life.

## CLASS PALLIOBRANCHIATA.

(Mantle-breathers, or *Brachiopods*.)

The Palliobranchiate bivalves may be considered as a parallel group with the Lamellibranchs, but inferior to them; as the Implacental as compared with the Placental Mammals. They are always attached, either by the surface of the valve, or by a peduncle passing through a hole, as in the Anomids. The resemblance however which caused Linnæus to unite *Terebratula* with *Anomia* is only superficial. The valves, instead of being side wings, are front and back shields. There are no true ligaments or hinge teeth. Above all, there are no gills; the breathing being performed by the general surface of the skin. The water-currents are established by the action of cilia and variously twisted "arms," which gave Lamarck the class-name *Brachiopoda*. But they are not, in any strict sense, arms or feet; not being used for locomotion; but on the contrary correspond to the *lips* of the Lamellibranchs, their office being to waft the food-particles to the mouth. They are generally fixed to a shelly skeleton within, the form of which is very characteristic of the genera. The valves of the Lamp-shells are fastened by interlocking teeth; but the work of ligaments is performed by a set of muscles which act in the opposite direction from the adductors. After the skin and lips are deducted, the body of the animal remains in but a small portion at the back of the shell, often partitioned off by a strong membrane, in the centre of which is the mouth.

As there is no special breathing organ, the mantle is more than usually supplied with blood vessels, and adorned with various filaments. The marks of the blood vessels may often be traced in the valves of fossil shells. These display far more of the peculiarities of the animal than do the valves of Lamellibranchs, in which the hinge is almost the only safe guide to their affinities. It is therefore fortunate that so



very large a proportion of the fossil bivalves, up to the tertiary age, belong to this class.

The structure of the shells is more simple than in the ordinary bivalve and univalve tribes. There is no distinction between the outer and inner layers; the whole consisting of long flattened prisms, arranged sideways. In most of the families these are traversed by numerous vertical tubes, which are trumpet-shaped outside and sometimes arborescent. As the valves open but a little way, and there are no specially directed breathing currents, the tubes which are no doubt occupied by prolongations from the mantle (which is not loose, as in ordinary bivalves) assist greatly either in the breathing or excretory functions. There are no pores in the internal lip skeleton.

In the ancient rocks both of the Old and New World, a *Lingula* is the first organic "footprint on the sands of time," the same generic form being still found in all the oceans of the globe. As we read onwards in the palæozoic chronicles, the forms, and still more the number of specimens, continue prominent, typical, and diagnostic above all other fossils until they reach their maximum of development in the Devonian ages. They continue extremely abundant throughout all the secondary and cretaceous ages; decreasing in comparative importance as the Lamellibranchs gradually appear. The *Productus* tribe does not enter the secondary period; the *Spirifers* and *Orthids* die out in the lower beds; while the *Rhynchonellids*, *Craniads*, and *Lingulas* have maintained their position, throughout all the changes in other races of animals, throughout all the fossil ages, to the present time. The *Terebratulids* were the latest to appear, not showing themselves decisively till the carboniferous age. Most of the tertiary and living forms belong to this group. Although the Palliobranchs are comparatively rare in the tertiary ages, the boreal Crag furnishes us with one of the largest species known. No members of this class attain the size of the Lamellibranchs; a more complete system for breathing and digestion being necessary to maintain a Scallop, a Panopæa, or a giant clam.

It used to be thought that the prevalence of Palliobranchs in any stratum was a sure evidence of deep-sea origin. It is true that they are found living in the greatest depths yet dredged; but species are also found in pools left by the retiring tide; and it is probable that many of the earliest rocks were deposited in comparatively shallow water. Although the recent shells are still rare in collections, they are common in the regions they inhabit; and as seventy species are already known, a greater number than has been discovered in any single secondary stratum, and as probably more than half the living forms are yet to be discovered, we have no right to say that the race are dying out. While some species are very local, other forms are widely diffused both in area and in time. The *Atrypa reticularis* is found through a whole series of strata, in the Old and in the New World; and *Spirifera striata* ranges from the Cordillera to the Ural mountains.

The fullest account of the shells and physiology of this class will be found in Davidson's treatise on the "British Fossil Brachiopoda," printed by the Palæontographical Society. A very full abstract of

everything known up to the date of publication, illustrated by many of the woodcuts in Davidson's work, will be found in "Woodward's Manual of the Mollusca," pp. 209-240, and 465-467. Additional genera are described by Prof. Hall in the annual Reports of the Regents of the University of New York. Those who wish to examine magnificent series of the shells of the older rocks, exhibiting the internal structure, are specially directed to the private collection of Prof. Hall, and to the Museum of the Geological Survey of Canada, arranged at Montreal under the direction of Sir W. Logan. The following is a sketch of the principal groups; but as the distinctions of the genera depend principally on the form of the lip-skeleton, which can be best understood by figures, they will only here be indicated.

*Family* TEREBRATULIDÆ. (*Lamp-Shells*.)

The Lamp-shells lie on their back, which is shielded by the smaller valve; the front valve bends over, and is pierced at the beak by a hole through which a peduncle anchors the animal to foreign objects. This presents a fanciful resemblance to the plug of the Anomiads; but, instead of being a side-bunch, produced by the foot, it is a lump which grows of itself behind the mouth; as though a Chinese mandarin were laid on his back and fastened by his hair-tail. So there is a resemblance between the mouth-arms of the Palliobranchs and the mouth-feelers of the four-gilled Cephalopods, Dr. Gray grouping these classes on each side of the Pteropods; but the likeness is almost as artificial as if we should compare the Star-fish with the Cuttles, both groups having locomotive organs round the mouth.

*Terebratula* proper is thin and smooth, with a very short loop. This only joins into a horseshoe; in the striated shells of *Terebratulina*, it unites into a ring. In *Waldheimia*, the shell is somewhat plaited, and the loop is very long and reflected. *Eudesia* differs in being sharply plaited. *Meganteris* is a long-looped Devonian form. In this group the loop is attached near the end of the back valve.

In *Terebratella* and its neighbors the loop is joined along the middle of the valve, to a perpendicular plate. The cretaceous *Trigonosemus* has a prominent, curved beak. *Lyra* (also cretaceous) has a long, ribbed beak. *Magas* has the reflected parts of the loop disunited. In *Bouchardia* the peduncle plate (called "deltidium," and separating the hole from the hinge) is blended with the shell. *Morrisia* is moored mouth-upwards, the hole being scooped out of both valves.

*Kraussia* is a southern form, with the beak truncated. *Megerlia* is also truncated, with the loop trebly attached. *Ismenia* has the valves ornamented with corresponding ribs; and *Kingena* has the surface spiny.

*Family* THECIDIADÆ.

*Thecidium* has no hole, but is attached by the beak to sea-urchins, corals, &c. *Argiope* resembles it in general aspect, but has a peduncle through the truncated valve. The mouth-arms are folded into four lobes; in *Cistella*, into two. *Stringocephalus* is a similar form from the Devonian; and *Zellania* resembles *Thecidium*, from the secondary rocks.

*Family* SPIRIFERIDÆ.

In this extinct group, the mouth-arms were supported by very large spiral coils, which occupy almost the whole of the sides of the shell. These are sometimes spiny, showing that they were covered with stiff cilia. In some members of this family the shell is pierced by tubes; in others not; but in metamorphic rocks it is very difficult to speak positively on this point. The species of *Spirifera* are found in palæozoic rocks all over the world. They are generally very transverse, like *Argiope*. *Cyrtia* has a pyramidal shape, with a prominent beak. *Spiriferina* and *Suessia* include the secondary forms, with a prominent plate inside the upper valve. *Athyris* (*Spirigera*) is shaped like a smooth *Terebratula*. *Merista* resembles it, with arched plates round the hinge. *Retzia* is punctured, like a *Terebratulina* with spiral arms. *Uncites* is not punctured, has no hinge area, and is furnished with a large concave deltidium, approaching *Pentamerus*.

*Family* RHYNCONELLIDÆ.

*Rhynconella* has long, spiral mouth-arms, directed inwards, (not outwards, as in the *Spirifers*,) and not supported by any shelly skeleton. The shell is not punctured, leaving the mantle loose. The living species are black and slightly plaited; the fossils are very numerous, and generally deeply plaited, with the margin of the valves twisted. In *Porambonites*, the surface is minutely pitted. *Camorphoria* has ridges supporting dental plates. In this respect it resembles *Pentamerus*, in which the plates are so magnified as nearly to divide each of the valves. They branch in the middle, so as to inclose a separate chamber in which the viscera were probably situated. *Atrypa* resembles *Rhynconella*, but with the mouth-arms calcified.

*Family* ORTHIDÆ.

The Orthids have punctate shells, generally very much depressed; with small beaks and straight hinge. They probably had horizontally-coiled spiral arms. In *Orthis*, the hinge-line is narrower than the shell, and both valves are convex. In *Orthisina*, it is wider. *Streptorhynchus* has the beak twisted. *Strophomena* is widest at the hinge-line. The valves are nearly flat during adolescence; when they approach maturity, they suddenly bend to one side. *Stropheodonta* has a toothed hinged-line. The restricted genus *Leptena* has the valves regularly curved. *Koninckia* has the valves rounded and smooth. *Davidsonia* was attached by the outer surface of the ventral valve. *Calceola* is generally reckoned with the "Rudistes;" all of which are, by Philippi and others, ranked with this family. It is funnel-shaped, resembling *Radiolites*; but the internal markings indicate strong affinities with the Orthids. The true *Calceolas* are a Devonian group; the so-called Carboniferous group, *Hypodema*, are believed to be Capulid Gastropods.

*Family* PRODUCTIDÆ.

In this singular group, the creatures were bent backwards; the back valve being concave, and the front valve very convex. They

were probably attached by the long hollow spines, which adorn the shells; and may have moored themselves in chinks, or partly buried in mud. *Productus* has the hinge-line linear, and is a Devonian group. *Aulosteges* has a hinge-area, like *Spondylus*. *Strophalosia* was attached by the beak of the front valve. The Silurian *Chonetes* has one row of spines along the hinge-line of the front valve.

#### Family CRANIADÆ.

The *Cranias* have lived from the palæozoic times till now. They have no hinge, and are attached by the front valve: the back valve being limpet shaped. The mouth-arms are free, supported by a nose-like projection in the front valve. The eye-like muscular scars give some of the species a rude resemblance to a skull. The valves are shelly, and very minutely punctured. The ancient *Pseudocrania* had the valves free. The position of *Spondilobolus* is uncertain.

#### Family DISCINIDÆ.

The shells of *Discina* are quite horny, and flexible when fresh. They are attached by a peduncle, passing through a chink in the lower valve. The mantle is surrounded by stiff bristles; but the cilia on the mouth-arms are very tender and flexible. The ancient fossils have been separated as *Orbiculoidea*. *Trematis* has convex valves, with a thickened hinge-margin. *Siphonotreta* is covered with hollow spines, with a tubular hole at the beak. *Acrotreta* is shaped like *Calceola*.

#### Family LINGULIDÆ.

As the *Lingulas* are the earliest, so they may be regarded as the lowest bivalve shells. They live half buried in sand or mud, often at slight depths; and, as their horny shells hang at the end of a very long peduncle, they have no slight resemblance to the Lepad Barnacles. Members of the group lived in all ages in the British seas, down to the Coralline Crag; and a species is still living on the Atlantic shores of North America. The Silurian form *Obolus* is nearly round, with a thickened hinge-margin.

### CLASS TUNICATA.

(*Tunicaries, or Cloaked Mollusks.*)

We have now completed our sketch of the shell-bearing classes of Mollusks. The remaining groups form a transition to the zoophytic condition of animal life. The higher Tunicaries offer many points of similarity with the sedentary Lamellibranchs; but the lower races lose their separate individuality, and become incorporated into a general mass of life, like the Polypes. Although not attractive to the general observer, they present many points of singular interest to the scientific student. They have lately been carefully examined and reported on by Huxley and Rupert Jones. The first group are the solitary or simple Ascidiæ.

*Family ASCIDIADÆ. (Sea-Squirts.)*

The Sea-squirts appear at first sight nothing but leathery bags, covered perhaps with sea-weed or other accretions. The presence of organic life is only made known to us by the violent jets of water which they force out when disturbed. This leathery bag or "test" takes the place of the shell in the bivalves. It is less distinctly animal in its nature than any other substance produced by sentient life, containing a large quantity of the vegetative *cellulose*. It is freely bored into by bivalve mollusks, such as *Crenella* and *Mytilimeria*. But under this test, is found a delicate mantle, like that of ordinary mollusks, united into a sac, and terminating in two openings, the inhalent and excurrent. The bulk of the body is occupied by the branchial sac, the mouth and all the viscera being collected into a small space at the bottom. If the test were removed and a Mya-shell placed over the inner mantle, the creature might pass for a Lamellibranch. But there are no true gills; the respiration being performed by the more or less wrinkled lining of the water chamber: there is no foot: the mouth has no lips to choose its food: there is no complete circulating system; the blood being carried backwards and forwards along the same vessels; and the reproductive functions are of so low an order that fresh individuals can be produced by budding, as in plants. The Ascidians are always fixed at the bottom of their squirts, and may often be gathered on the fronds of sea-weeds, shells, &c. In many places they are taken to market, and even considered dainty articles of food. The *Ascidia* vary from one to six inches in length, and often are brilliantly colored within. *Molgula* and *Glandula* have globular bodies, differing in the number of lobes at the apertures. *Cynthia* has a basket-shaped body, with two ovaries; *Dendrodoa* has only the left, and *Pandocia* the right ovary. *Pera* has a pear-shaped body, scarcely adhering. *Pelonœa* has a long body, ending in the two pipes, and looks like the outside portion of a *Panopœa*. *Chelyosoma* is a Greenland form, with a tortoise-shaped body. *Boltenia* is kidney-shaped, resting on a long stalk, on which the young ones sometimes grow.

*Family CLAVELLINIDÆ. (Social Ascidians.)*

Here, for the first time as we descend downwards in the animal scale, we meet with several living creatures, each having their own organs of individual life, but all connected together into a common life by prolongations from a central stem or creeper, in which the common blood keeps circulating in opposite directions. The compound creature is called a *Zooid*. The creatures are quite transparent, and very small. New creatures are formed by buddings-off from the common stem, as well as by fresh eggs. *Clavellina* looks like a bunch of *Cineras*. *Perophora* grows on sea-weed, like little specks of jelly dotted with orange and brown. *Syntethis* grows in dahlia-shaped masses six inches across. The zooid of *Chondrostachys* has a long cylindrical stem.

*Family BOTRYLLIDÆ. (Compound Ascidians.)*

These creatures have their tests fused into a common mass, so that each zooid looks like a single animal outside ; but the individuals are found to be separate within. In the *Botryllians*, the individuals are united into systems round common excretory cavities. In the *Didemnians*, the chest and abdomen are distinct. In the *Polyclinians*, there is a chest, with the breathing organs ; an upper abdomen, with the digestive organs ; and a lower abdomen, with the heart (so called) and reproductive organs.

In *Botryllus*, the breathing-holes are star-shaped, the cloaca being poured into a common sewer. In *Botrylloides*, the stars are more irregular, and the animals are vertical.

The zooid of *Didemnum* is very irregular, the individuals with a pedunculate abdomen. In *Eucelium*, the animals are scattered, or arranged in quincunx. *Leptoclinum* makes thin, variously colored zooids, adhering to the roots of tangles. *Distomus* and *Diazona* are bistellate, the latter being flower-shaped, like *Synthys*.

*Sigillina* is also bistellate ; *i. e.* both the mouth and anal orifice are rayed. The zooid grows like a plantain. In the remaining genera, the mouth only is rayed. *Polyclinum* has a fungus-shaped mass. The *Aphidia* or Sea-figs have often been confounded with *Alcyonium*. *Sidnyum* forms transparent, amber-colored masses under shelving rocks at extreme low water. *Synæcium* is an arctic form, with a stalked zooid. *Amœrcœcium* has a common central cloaca to the pod-shaped zooid.

*Family PYROSOMIDÆ.*

The *Pyrosomes* combine in innumerable numbers to form hollow transparent tubes, open at one end, which receive the common cloaca. These tubes, or zooids, are from two to fourteen inches long, and an inch across. The mouths are outside ; and by the combined force of the exhalent currents, the zooid is driven forward in the open sea with the closed end forward, reminding us in a feeble manner of the squirt-swimming of the Cuttles. They increase by buds or by eggs : and often fill the sea in such vast numbers as greatly to incommode the nets of fishermen. At night they are brilliantly phosphorescent, resembling "incandescent cylinders of iron." Humboldt observed them as forming lights, eighteen inches in diameter, by which the fishes were made visible.

*Family SALPIDÆ.*

The *Salpas* first exhibit to us the zoophitic condition of alternate generation. No *Salpa* is like its parent or its child ; but always resembles its grandparent or grandchild. The creatures of one generation therefore do not exhibit to us the whole Salpoid structure. Just as in the higher animals we must have two individuals, male and female, before we can gain a complete idea of the species ; so in the *Salpas* we must see two generations, mother and child, before we can understand the complete Salphine zooid. The *Salpas* are found under two very contrary conditions ; as free individuals and as serpentine

chains of compound animals. That they were the same, was first discovered by Chamisso, the author of the well-known "Man without a Shadow." The solitary Salp always gives birth to the compound, and those again to the single. *Doliolum* is intermediate between *Salpa* and *Pyrosoma*.

*Family* APPENDICULARIADÆ. (*Larval Ascidians*.)

The minute *Appendicularias* appear as cloudy patches of red coloring matter in the northern seas. They are little tadpole-shaped creatures, and resemble the larval stage of the higher tribes of Tunicaries, arrested at the first period of growth.

### CLASS POLYZOA.

Among the creatures generally grouped together as zoophytes, and forming the structures usually known as "Corallines," "Sea-weeds," &c., are many which are found to have a much more complex organization than the rest. There is an excurrent opening distinct from the inhalent cavity; and though their general habit of life resembles the true zoophytes, yet there is sufficient analogy between them and the compound Tunicaries to entitle them to a place in the molluscan sub-kingdom. They differ from even the lowest Tunicaries, in not having any special circulating vessels; the fluids being generally transmitted through the transparent mass of the tiny bodies. They have been designated both as *Polyzoa* and *Bryozoa*; the former name being the earliest, the latter the most distinctive as a class. By some authors they are considered as superior Radiates, by others as degraded Mollusks. The balance of characters seems in favor of the latter view; but as they are more conveniently studied in common with the true zoophytes, and are generally described in treatises concerning the latter, they will not be further considered here. Those who are at the sea-shore, and can examine the "sea-rats" and *Lepralias* in their living state under the microscope, will do well to examine the differences between them and the common Sertularian Polypes. Some of the forms are peculiar to fresh waters. The test formed by their compound zooids is often somewhat calcareous. Their remains are extremely abundant in the Coralline Crag; and even in the palæozoic rocks, they play an important part among the fossil keys to knowledge. It must be borne in mind however that many of the objects described loosely as *Bryozoa* have no relation to this class.

Those who desire information on this interesting class of creatures are referred to "Johnstone's British Zoophytes," and to the works of George Busk, Esq., published by the British Museum.

On bringing to a close this brief digest of our existing knowledge of molluscous animals, any one who will take the trouble to compare the nomenclature and arrangement here adopted with that of any one or more of the principal treatises on the subject, will be struck with the general want of harmony which prevails among the different authorities. It will not help us out of our difficulties to ignore their exist-

ence. In the old days when all knowledge was supposed to be centered in Lamarck, we had nothing to do but to study his system and follow it. We are now turned loose on a new sea of inquiry; where every voyager makes his own discoveries, which is right; and his own speculations, which may be correct or very erroneous.

Our uncertainties for want of knowledge are quite sufficiently discouraging; but for these we must be prepared. With every fresh, patient, and honest observation, these will be steadily lessened, in spite of the prejudice and human tempers which ought not indeed to be allowed to enter into the domain of science, but alas! are to be found there as rife as in any other department where men enter on each other's paths. And it ought to be an incentive to pursue this branch of study that there is so much to be done; and so much, too, the materials for which are easily accessible. The principal requisites to insure really useful results are not indeed great talents or special acquirements, which fall to the lot of but few; but what an ordinary person may possess himself of, an accurate eye, patience, and honesty.

It is well, in the present state of science, to take nothing on trust. What is copied from book to book, and what is repeated from figure to figure, may be correct; "but then, on the other hand, it may not." Very few can examine all things with their own eyes; and the greatest authors take many things on trust, which humble students may prove to be unfounded. It is a mistake to suppose that the evidence of the senses is infallible. The eye has to be trained to see, just as much as the ear to appreciate false and true harmonies, or the hand to discriminate weights. Very few persons at the beginning of their investigations see things in the microscope as they do after long study. The best artist, if required to draw a shell, might very likely overlook features which a student has learned to see at once. Therefore let a man work some time, comparing his observations with the books, and repeating them under different conditions, before he considers himself competent to trust his own eyesight.

Let the student especially avoid hasty conclusions. Because character A is found to be coördinate with character *a* in one class of shells, let him not infer that it is so in another; still less that character B is coördinate with character *b*. The following table may serve as a lesson of caution, to show how little can be gathered from general similarity in appearance. It furnishes some of the more striking examples of Gasteropods similar in form of shell, but known to belong to different families by peculiarities in the animal.

TABLE OF SIMILAR SHELLS, BELONGING TO DIFFERENT FAMILIES OR GENERA.

Murex, <i>Muricidæ</i> .	Cerastoma and Vitularia, <i>Purpuridæ</i> .	Ranella and Triton, <i>Tritonidæ</i> .
Chrysodomus, <i>Muricidæ</i> .	Strombella, <i>Buccinidæ</i> .	Io, <i>Melaniadæ</i> .
Engina, <i>Muricidæ</i> .	Ricinula, <i>Purpuridæ</i> .	
Anachis, <i>Muricidæ</i> .	Nitidella, <i>Purpuridæ</i> .	Columbella, <i>Buccinidæ</i> .
Cominella, <i>Muricidæ</i> .	Buccinum, <i>Buccinidæ</i> .	Truncaria, ? <i>Purpuridæ</i> .
Pisania, <i>Muricidæ</i> .	Iopas, <i>Purpuridæ</i> .	Peristernia, <i>Fasciolaridæ</i> .



- Pyruia*, *Pyruidae*. *Fulgur*, *Fascioliariadæ*. *Rapana*, *Purpuridæ*.  
*Ficula*, *Ficulidæ*.  
*Leucozonia*, *Fascioliariadæ*. *Monoceros*, *Purpuridæ*.  
*Mitra*, *Fascioliariadæ*. *Turricula*, *Turriculidæ*. *Volutomitra*, *Volutidæ*.  
*Aulica*, *Volutidæ*. *Amoria*, *Do*.  
*Metula*, ? *Muricidæ*. *Daphnella*, *Pleurotomidæ*.  
*Marginella*, *Marginellidæ*. *Erato*. *Cypræidæ*.  
*Cerithiopsis*, *Cerithiopsidæ*. *Fastigiella*, ? *Fascioliariadæ*. *Cerithium*,  
*Cerithiadæ*.  
*Velutina*, *Velutinidæ*. *Capulus*, *Capulidæ*. *Otina*, *Otinidæ*.  
*Sigaretus*, *Naticidæ*. *Lamellaria*, *Lamellariadæ*. *Stomatella*, *Stomatidæ*.  
*Drillia*, *Pleurotomidæ*. *Clionella*, *Melaniadæ*.  
*Lunatia*, *Naticidæ*. *Lacuna*, sp. *Lacunidæ*. *Pachistoma*, *Ampullariadæ*.  
*Naticina*, *Naticidæ*. *Narica*, *Naricidæ*. *Fossarus*, *Litorinidæ*.  
*Menestho*, *Pyramidellidæ*. *Mesalia*, *Turritellidæ*. *Melania*, *Melaniadæ*.  
*Helis*, *Pyramidellidæ*. *Turritella*, *Turritellidæ*.  
*Top-shells in general*, e. g. : *Solarium*, *Solariadæ*. *Phorus*, *Phoridæ*.  
*Bisella*, *Litorinidæ*. *Trochita*, *Calyptræidæ*. *Trochatella*, *Helicidæ*.  
*Especially* : *Phorus*, *Phoridæ*, *Guildfordia*. *Turbidæ*. *Torinia*, *Solariadæ*.  
*Monilea*, *Trochidæ*. *Infundibulum*, *Trochidæ*. *Trochita*, *Calyptræidæ*.  
*Costellaria*, *Strombidæ*. *Aporrhais*, *Aporrhaidæ*.  
*Tanalia*, *Paludinidæ*. *Paludomus*, *Melaniadæ*.  
*Vermetus*, *Vermetidæ*. *Serpula*, ANNELIDS.  
*Dentalium*, *Dentaliadæ*. *Ditrupa*, ANNELIDS.  
*Planorbis*, *Planorbidæ*. *Marisa*, *Ampullariadæ*. *Polygira*, *Helicidæ*.  
*Limpets in general*, e. g. : *Patella*, *Patellidæ*. *Acmaea*, *Acmaeidæ*.  
*Amalthea*, *Capulidæ*. *Gadina*, *Gadiniadæ*. *Siphonaria*, *Siphonariadæ*.  
*Broderipia*, *Stomatidæ*. *Umbrella*, *Umbrellidæ*.  
*Especially* : *Nacella*, *Patellidæ*. *Ancylus*, *Planorbidæ*. *Latia*, *Planorbidæ*.  
*Crepidula*, *Calyptræidæ*. *Tylodina*, *Umbrellidæ*. *Scurria*, *Armæidæ*.  
*Amphibola*, *Amphibolidæ*. *Scissurella*, *Scissurellidæ*.  
*Achatina*, *Helicidæ*. *Glandina*, *Testacellidæ*, &c. &c.

A similar table might easily be prepared of shells very greatly differing in appearance, which are known to belong to the same family.

This branch of study has been favored with quite a sufficient number of hasty generalizations to last for some time to come. What we want now is patient verification of the past, and cautious observation for the future. "*Non omnes possumus omnia*," and every man is not bound to do his work well; because he cannot; but he *is* bound honestly to use all the materials at his command. There is so much yet to be known about the commonest land and fresh-water shells, in their anatomy, habits, distribution, and specific differences; and there are so many materials hoarded up in museums awaiting the study of nat-

uralists, that all who are disposed to train their eyes and set to work can easily find the means for useful service.

The objects of the Smithsonian Institution are both the *increase* and the *diffusion* of knowledge. So very much confusion is constantly arising from wrongly or uncertainly named specimens, that those who are not prepared to increase existing knowledge can make themselves very useful simply by diffusing the knowledge of others. On comparing together the American shells given me by a number of accurate and trustworthy American naturalists, I find myself considerably bewildered, not merely by the wrong names which are given, but by names given as by Lea, Say, and other distinguished authors, which contradict themselves, and therefore cannot be depended upon. These difficulties are to be met by the copious diffusion of specimens *named from types*. All that can thus be vouched for have a peculiar value, especially in a foreign country: and if collectors will merely amass a multitude of specimens, and see to their being named by those who possess the typical knowledge, the Smithsonian Institution will see to their being made available for the purposes of science. It is not necessary for the uses of science that the name given should ultimately stand as the correct one. Whether, *e. g.*, among the Unios, a name of Lea or of Rafinesque be permanently chosen, matters little. What we want to know is that such a shell is really the Unio — of Lea, or the Unio — of Conrad. When it is known accurately what each author means by his own descriptions, his successors have something tangible to work upon. At present a large proportion of every author's time is taken up with trying to find out, and that under ordinary circumstances with necessary errors, what his predecessors mean. If this is true even of the most careful writers, such as C. B. Adams, Conrad, &c, what can be said of the imagination of Rafinesque.

As to questions of generic nomenclature, it is hoped that the present climax of confusion will make the necessity felt of agreeing on some common basis. At present some writers endeavor to follow the rules of the British and American associations; others avowedly set them at defiance. To revive the careless work of old writers, to the upsetting of those whose useful toil has been recognized by general acceptance, appears worse than folly. If any one will compare the names of the Messrs. Adams and of Dr. Gray, who profess to follow the same rule of absolute priority, it will be found that ancient genera were so ill defined that even those who most desire to understand them, have interpreted them quite differently. Under these circumstances, it is well for ardent young naturalists not necessarily to adopt all the interpretations now offered of old names, from the bewitching love of novelty; but to remember that *use* and *accuracy* are matters far more important than supposed justice to men whose works might as well have been forgotten. Every naturalist ought to start with a feeling that it is of no consequence what becomes of his own names and his own reputation, if the "increase and diffusion of knowledge among men" is promoted by his own retirement; and what he thus feels for himself, he should be willing to accord to those whose works are as inaccessible as they have proved to be injuriously confusing. In ar-

ranging the nomenclature for this report, we have endeavored to preserve as far as possible the names in common use; and when dead names have been revived, they are taken not as the works of Link or Klein, but as the names of Gray or Adams, who have given an accurate diagnosis to what before was of uncertain import. By all means, let us spend our time in the living present. The naturalist is not required to be the archæologist.

The study of Mollusks in connection with their geographical distribution is a matter of the very first importance. For this reason, all persons who will carefully note what shells are found living, what dead, and what fossil, in their own localities, and distribute them accordingly, may be rendering the most essential service. Our knowledge of the American faunas is by no means so complete as of those of Europe: and as men of intelligence are now to be found in every part of the continent, and the young are now learning freely in the public schools what in the Old World has long been the property only of the learned few, we ought to find our information accumulating with giant strides.

To young naturalists, we may be allowed to say that he who will carefully work up the labors of his predecessors, and make out their synonymy, is doing far more useful and more honorable labor than he who only affixes his own name to a number of fresh species.

If space and time had permitted, it might have been interesting to have followed up this sketch of the generic forms of Mollusks, with an account of their geographical and geological distribution. But this has been done so admirably by Woodward, in the latter part of his "Manual of Mollusca," that there is scarcely occasion to do more than to refer the reader to his pages. We have followed the plan of Gray and Adams, of free multiplication of families and genera, rather than that of Woodward of only keeping a few leading distinctions, simply because in the actual work of identifying shells we have found it far more convenient; but a comparison of all ordinary books with the "Manual" only amazes us more and more at the vast amount of patient investigation, of accumulated facts, and of philosophic judgment which its author has condensed into a small volume; and it is equally surprising how, with all the beautiful engravings and woodcuts, it can be sold (as it is in London) for \$1 32.

The days are coming when books will be more accessible to students. The contemplated series of text books on American Natural History which the Smithsonian Institution propose to issue will be of essential service. The cheap figures of Chénu will form a portable collection of shells for those who have not access to museums. And to those who cannot obtain even the cheapest of books, there lies, spread out before them, in every stream, in every wood, on every prairie, at every shore, the one grand book of Nature; ever ancient and yet ever new; in which the still small voice of its Life-giver is ever inviting us to come unto Him, and learn; to come unto Him, and labor; to come unto Him, and rejoice in his boundless love.

# GENERAL VIEWS ON ARCHÆOLOGY.

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A century has scarcely elapsed since the time when it would have been thought impossible to reconstruct the history of our globe prior to the appearance of mankind; but though contemporary historians were wanting during this immense pre-human era, this era has not failed to leave us a well-arranged series of most significant vestiges. The animal and vegetable tribes which have successively appeared and disappeared have left their fossil remains in the successively deposited strata. Thus has been composed, gradually and slowly, a history of creation written, as it were, by the Creator himself. It is a great book, the leaves of which are the stratified rocks, following each other in the strictest chronological order, the chapters being the mountain-chains. This great book has long been closed to man; but science, constantly extending its realm and improving its method of induction, has taught the geologist to study those marvelous archives of creation, and we behold him now unfolding the past ages of our world with a variety of details and a certainty of conclusions well calculated to inspire us with grateful admiration.

The development of Archæology has been very similar to that of Geology. Not long ago we should have smiled at the idea of reconstructing the bygone days of our race previous to the beginning of history properly so called. The void was partly filled up by representing that ante-historical antiquity as having been only of short duration, and partly by exaggerating the value and the age of those vague and confused notions which constitute tradition.

It seems to be with mankind at large as with single individuals. The recollections of our earliest childhood have entirely faded away up to some particular event which had struck us more forcibly, and which alone has left a lasting image amidst the surrounding darkness. Thus, excepting the idea of a deluge which exists among so many nations, and therefore appears to have originated before the emigration of those same nations, the infancy of mankind, at least in Europe, has passed without having any reminiscences; and history fails here entirely, for what is history but the memory of mankind.

But before the beginning of history there were life and industry, of which various monuments still exist; while others lie buried in the

soil, much as we find the organic remains of former creations entombed in the strata composing the crust of the globe. The antiquities enact here a similar part to that of the fossils; and if Cuvier calls the geologist an antiquarian of a new order, we can reverse that remarkable saying, and consider the antiquarian as a geologist, applying his method to reconstruct the first ages of mankind previous to all recollection, and to work out what may be termed pre-historical history. This is **Archæology** pure and proper. But Archæology cannot be considered as coming to a full stop with the first beginning of history, for the further we go back in our historical researches, the more incomplete they become, leaving gaps which the study of material remains, helps to fill up. Archæology, therefore, pursues its course in a parallel line with that of history, and henceforth the two sciences mutually enlighten each other. But with the progress of history the part taken by Archæology goes on decreasing, until the invention of printing almost brings to a close the researches of the antiquarian.

To pursue geological investigations, we must first examine the present state of our planet, and observe its changes—that is, we must begin by physical geology. This supplies us with a thread of induction to guide us safely in our rambles through the past ages of our earth, as Lyell has so admirably set forth; for the laws which govern organic creation and the inorganic world are as invariable as the results of their combinations and permutations are infinitely varied, science revealing to us everywhere the perfect stability of causes with the diversity of forms.

So, to understand the past ages of our species, we must first begin by examining its present state, following man wherever he has crossed the waters and set his foot upon dry land. The different nations which at present inhabit our earth must be studied with respect to their industry, their habits, and their general mode of life. We thus make ourselves acquainted with the different degrees of civilization, ranging from the highest summit of modern development to the most object state, hardly surpassing that of the brute. By that means ethnology supplies us with what may be called a contemporaneous scale of development, the stages of which are more or less fixed and invariable; whilst Archæology traces a scale of successive development, with one movable stage passing gradually along the whole line.<sup>1</sup>

Ethnography is, consequently, to Archæology what physical geography is to geology, namely: a thread of induction in the labyrinth of the past, and a starting point in those comparative researches of which the end is the knowledge of mankind, and its development through successive generations.

In following out the principles above laid down, the Scandinavian *savants* have succeeded in unraveling the leading features in the progress of pre-historical European civilization, and in distinguishing

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<sup>1</sup> Some naturalists see a correspondence of the same sort between embryology and comparative anatomy, for they consider the human embryo as passing during its development through the different stages of the scale of animal creation, or, at least, as passing through the different states of the embryos of the different stages of that scale.

three principal eras, which they have called the **Stone-age**, the **Bronze-age**, and the **Iron-age**.<sup>1</sup>

This great conquest in the realm of science is due chiefly to the labors of Mr. Thomsen, director of the Ethnological and Archæological Museums at Copenhagen,<sup>2</sup> and to those of Mr. Nilsson, professor at the flourishing University of Lund, in Sweden.<sup>3</sup> These illustrious veterans of the school of northern antiquarians have ascertained that Europe, at present so civilized, was at first inhabited by tribes to whom the use of metal was totally unknown, and whose industry and domestic habits must have borne a considerable analogy to what we now see practiced among certain savages. Bone, horn, and chiefly flint, were then used, instead of metal, for manufacturing cutting-instruments and arms. This was the **Stone-age**, which might also be called the first great phase of civilization.

The earliest settlers in Europe apparently brought with them the art of producing fire. By striking iron-pyrites (sulphuret of iron) against quartz, fire can be easily obtained. But this method can only have been occasionally used, and seems to have been confined to some native tribes in Terra del Fuego.<sup>4</sup> The usual mode has been evidently that of rubbing two sticks together; but, on further reflection, it is easy to perceive that this was a most difficult discovery, and must at all events have been preceded by a knowledge of the use of fire as derived from the effects of lightning or from volcanic action.

The Stone-age was, therefore, probably preceded by a period perhaps of some length, during which man was unacquainted with the art of producing fire. This, according to Mr. Flourens, indicates that the cradle of mankind was situated in a warm climate.<sup>5</sup>

The art of producing fire has been perhaps the greatest achievement of human intelligence. The use of fire lies at the root of almost every species of industry; it enables the savage to fell trees, as it allows civilized nations to work metals. The importance is so great, that, deprived of it, man would perhaps scarcely have risen above the condition of the brute. The ancients already were sensible of this. Witness the fable of "Prometheus." As to their sacred perpetual fire, its origin seems to lie in the difficulty of procuring it, thereby rendering its preservation essential.

In Europe the Stone-age came to an end by the introduction of bronze. This metal is an alloy of about nine parts of copper and one

<sup>1</sup> The history of Danish Archæology has been sketched by T. Hindenburg. (See "Dansk Maanedsskrift," I. 1859.)

<sup>2</sup> "Ledetraad til nordisk Oldkyndighed." Copenhagen, 1836. Published in English by Lord Ellesmere under the title of "A Guide to Northern Antiquities." London, 1848.

<sup>3</sup> Nilsson. "Scandinaviska nordens urinvonare." Lund, 1838—1843.

<sup>4</sup> Weddell, "A Voyage towards the South Pole in 1822, 1824." London, 1827. P. 167.

<sup>5</sup> Flourens's "De la Longevité Humaine." Paris, 1855. P. 127. Man, from the construction of his teeth, his stomach, and his intestines, is primitively frugivorous, like the monkey. But the frugivorous diet is the most unfavorable, because it constrains its followers perpetually to abide in those countries which produce fruit at all seasons, consequently in warm climates. But, once the art of cooking introduced, and applied both to animal and vegetable productions, man could extend and vary the nature of his diet. Man has, consequently, two diets: the first is primitive, natural, and instinctive, and by it he is frugivorous the second is artificial, being due entirely to his intelligence, and by this he is omnivorous.

part of tin.<sup>1</sup> It melts and moulds well; the molten mass, in cooling, slowly acquires a tolerable degree of hardness—inferior to that of steel, it is true, but superior to that of very pure iron. We therefore understand how bronze would long be used for manufacturing cutting-instruments, weapons, and numerous personal ornaments. The northern antiquarians have very properly called this second great phase in the development of European civilization the **Bronze-age**.

The bronze articles of this period, with a few trifling exceptions, have not been produced by hammering, but have been cast, often with a considerable degree of skill. Even the sword-blades were cast, and the hammer (of stone) was only used to impart a greater degree of hardness to the edge of the weapon.

The Bronze-age has, therefore, witnessed a mining industry which was completely wanting during the Stone-age. Now the art of mining is so essential to civilization, that without it the world would perhaps yet be exclusively inhabited by savages. It is, therefore, worth our while to inquire more closely into the origin of bronze.

Copper was not very difficult to obtain. In the first place, virgin copper is not exceedingly scarce. Then the different kinds of ore which contain copper, combined with other elements, are either highly colored, or present a marked metallic appearance, and are consequently easily known; they are, besides, not hard to smelt, so as to separate the metal. Finally, copper-ore is not at all scarce, it is met with in the older geological series of most countries.

Virgin tin is unknown, but tin-ore exists, of a dark color, and very easy to smelt. However abundant copper may be, tin is of rare occurrence. Thus the only mines in Europe which produce tin at the present day are of Cornwall, in England, and of the Erzgebirge and Fichtelgebirge, in Germany.

But the question arises whether, previous to the discovery of bronze, man, owing to the great rarity of tin, may not have begun by using copper in a pure state. If so, there would have been a copper-age between the stone and bronze-ages.

In America this has really been the case. When they were discovered by the Spaniards, both the two centres of civilization, Mexico and Peru, had bronze composed of copper and tin, which was used for manufacturing arms and cutting-instruments, in the absence of iron and steel, which were unknown in the New World; but the admirable researches of Messrs. Squier and Davis on the antiquities of the Mississippi valley<sup>2</sup> have brought to light an ancient civilization of a remarkable nature, and distinguished by the use of raw virgin copper, worked in a cold state by hammering without the aid of fire. The reason of its being so worked lies in the nature of pure copper, which, when melted, flows sluggishly, and is not very fit for casting. A

<sup>1</sup> Bronze is still used for casting bells, cannon, and certain parts of machinery. It must not be confounded with common brass, which is a compound of copper and zinc, much less hard, and appearing only in the Iron-age.

<sup>2</sup> Squier and Davis. "Ancient Monuments of the Mississippi Valley." Smithsonian Contributions to Knowledge." Washington, 1848. It is one of the most splendid archæological works ever published.

peculiar characteristic of the metal, that of occasionally containing crystals of virgin silver, betrays its origin, and shows that it was brought from the neighborhood of Lake Superior. This region is still rich in metallic copper, of which single blocks attaining a weight of fifty tons have lately been discovered. There was even found at the bottom of an old mine a great mass of copper, which the ancients had evidently been unable to raise, and which they had abandoned, after having cut off the projecting parts with stone hatchets.<sup>1</sup>

The date of this American age is unknown; all we know is that it must reach as far back as ten centuries at least, that space of time being deemed necessary for the growth of the virgin forests, now flourishing upon the remains of that antique civilization of which the modern Indians have not even retained a tradition.

It is finally worthy of remark that the "mound-builders," as the Americans call the race of the Copper-age, seem to have preceded and prepared the Mexican civilization, destroyed by the Spaniards; for in progressing southwards, a gradual transition is noticed from the ancient earth-works of the Mississippi valley to the more modern constructions of Mexico, as found by Cortez.

In Europe the remains of a copper-age are wanting. Here and there a solitary hatchet of pure copper is found; but this can easily be accounted for by the greater frequency of copper, while tin had usually to be brought from a greater distance, so that its supply was more precarious.

Europe did not witness the regular development of a copper-age. It seems, according to M. Worsaac's very just remark, that the art of manufacturing bronze was brought from another quarter of the world, where it had been previously invented. It was most probably some region in Asia, producing both copper and tin, where these two metals were first brought into artificial communication, and where also traces of a still earlier copper-age are likely to be found.

An apparently serious objection might be started here, by raising the question how mines could be worked without the aid of steel. This, however, is sufficiently explained by the fact that the hardest rocks can be easily managed by the agency of fire. By lighting a large fire against a rock, the latter is rent and fissured, so as to facilitate considerably its quarrying. This method was frequently employed when wood was cheaper, and is even practiced in the present day in the mines of the Rammelsberg, in Germany, where it facilitates the working of a rock of extreme hardness.

That metal of dingy and sorry appearance, but more precious than gold or the diamond—iron—at length appears, giving a wonderful impulse to the progressive march of mankind, and characterizing the third great phase in the development of European civilization, very properly called the **Iron-age**.

Our planet never yields iron in its metallic or virgin state, for the simple reason that it is too liable to oxydation. But among the

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<sup>1</sup> Lapham. "The Antiquities of Wisconsin." Smithsonian Contributions to Knowledge, p. 76, 1855.



ærolites there are some composed of pure iron, with a little nickel, which alters neither the appearance nor the qualities of the metal. Thus the celebrated meteoric stone met with by Pallas in Siberia was found by the neighboring blacksmiths to be malleable in a cold state.<sup>1</sup> Meteoric iron has even been worked by tribes to whom the use of common iron was unknown. Thus Amerigo Vespucci speaks of savages near the mouth of the La Plata, who had manufactured arrow-heads of iron derived from an ærolite.<sup>2</sup> Such cases are certainly of rare occurrence, but they are not without their importance, for they explain how man may probably have first become acquainted with iron, and they also account for the occasional traces of iron in tombs of the Stone-age, if, indeed, this fact be well established.

It is, notwithstanding, evident that the regular working of terrestrial iron-ore must have been a necessary condition of the commencement and progress of the Iron-age.

Now iron-ore is generally found in most countries, but it has usually the appearance of stone, being distinguished neither by its weight nor color. Moreover, its smelting requires a much greater degree of heat than copper or tin, and this renders its production considerably more difficult than that of bronze.

But even when iron had been obtained, what groping in the dark, and how much laboriously accumulated experience did it not require, to bring forth at will bar-iron or steel! Chance, if chance there be, may have played a part in it; but as chance only favors those privileged mortals who combine a keen spirit of observation with serious meditation and with practical sense, the discovery was not less difficult nor less meritorious. We need not, then, be surprised if man arrived but tardily at the manufacture of iron and steel, which is still daily being improved.

In Carinthia traces of a most primitive method of producing iron have been noticed. The process seems to have been as follows: On the declivity of a hill an excavation was dug, in which was lighted a large fire. When this began to subside, fragments of very pure ore (hydroxyd) were thrown into it, and covered by a new heap of wood. When all the fuel had been consumed, small lumps of iron would then be found among the ashes.<sup>3</sup> All blowing apparatus was in this manner dispensed with—an important fact when we come to consider how much its use complicates the metallurgical operations, because it implies the application of mechanics. Thus, certain tribes in southern Africa, although manufacturing iron and working it tolerably well, have not achieved the construction of our common kitchen-bellows, apparently so simple; they blow laboriously through a tube, or by means of a bladder affixed to it.

The Romans produced iron by the so-called Catalonian process, and the remains of Roman works of that description have been discovered

<sup>1</sup> Pallas. "Voyages en Russie," Paris, 1793, vol. iv, p. 595. There was but one mass of meteoric iron; it weighed 1,600 lbs.

<sup>2</sup> "Smithsonian Contributions to Knowledge," vol. ii, art. 8, p. 178.

<sup>3</sup> Communicated to the author by mining-engineers in Carinthia.

and investigated in Upper Carniola, Austria<sup>1</sup>. The Catalonian forge is still used in the Pyrenees, where it yields tolerable results; but it consumes a large quantity of charcoal, requires much wind, and is only to be applied to pure ore containing but a very small proportion of earthy matter, producing scoriæ. The process, in fact, consists in a mere reduction, with a soldering and welding together of the reduced particles, without the metal properly melting. According to the manner in which the operation is conducted, bar-iron or steel are obtained at will. This direct method dispenses with the intermediate production of cast-iron, which was unknown to the ancients, and which is now the means of producing iron on a great scale.

Silver accompanied the introduction of iron into Europe—at least, in the northern parts; whilst gold was already known during the bronze-age. This is natural, for gold is generally found as a pure metal, while silver has usually to be extracted from different kinds of ore, by more or less complicated metallurgical operations—for example, cupellation.

With iron appeared also, for the first time in Europe, glass, coined money—that powerful agent of commerce—and finally the alphabet, which, as the money of intelligence, vastly increases the activity and circulation of thought,<sup>2</sup> and is sufficient of itself to characterize a new and wonderful era of progress. From thence we can date the dawn of history and of science, in particular of astronomy.



Fig. 1. (4)



Fig. 2. (4)



Fig. 3. (4)

The fine arts presented, with the introduction of iron in Europe, a new and important element indicating a striking advance. During the stone-age, but more so in the bronze-age, the natural taste for art reveals itself in the ornaments bestowed upon pottery and metallic objects. These ornaments consist of chevrons, circles, and zig-zag, spiral, and S-shaped lines, the style bearing a geometrical character, but showing pure taste and real beauty of its kind, although devoid of

<sup>1</sup> Jahrbuch der K. K. geologischen Reichsanstalt. Vienna, 1850, vol. ii, p. 199. Carinthia and Upper Carniola formed part of the Roman province Noricum, celebrated for its iron.

<sup>2</sup> "The circulation of ideas is for the mind what the circulation of specie is for commerce—a true source of wealth." C. V. de Bonstetten. "L'homme du midi et l'homme du Nord." Geneva, 1826, p. 175.

all delineations of animated objects, either in the shape of plants or animals. It is only with the Iron-age that art, taking a higher range, rose to the representation of plants, animals, and even of the human frame. No wonder, then, if idols of the Bronze-age as well as of the Stone-age are wanting in Europe. It is to be presumed that the worship of fire, of the sun, and of the moon, was prevalent in remote antiquity—at least during the Bronze-age, perhaps also during the Stone-age.

The preceding pages present a sketch, certainly very rough and imperfect, of the developments of civilization. They establish, however, in a very striking manner, the fact of a progress, slow, but uninterrupted and immense, when the starting point is considered. The physical constitution of man has naturally benefitted by it. The details contained in the treatise of which the present paper forms the introduction prove that the human race has been gradually gaining in vigor and strength since the remotest antiquity.<sup>1</sup> The domestic animals also—the dog first, then the horse, the ox, and the sheep have shared in this physical development. Even the vegetable soil has been gradually improving since the Stone-age—at least in Denmark. And yet there are persons who deny all general progress, seeing everywhere nothing but decay and ruin, like that worthy specimen of a northern pessimist who exclaimed, “See how man has degenerated; he has even lost his likeness to the monkey!”

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## I. KJOEKKENMOEDDING.

**General View.**—On certain points of the Danish shore there are found heaps, some times enormous, of marine shells, which were at first taken to be natural deposits, indicating an ancient level of the sea higher than at present, or, to speak more correctly, a level of the dry land lower than the present one.

But in the natural deposits along the coast we observe an assemblage of individuals of all ages, young and old, belonging to the littoral mollusk fauna, whilst here the younger are wanting, and we discover merely adult individuals belonging to a small number of species, which have not all even the same habitat, as the oyster and the littorine, and could not therefore be met naturally in each other's company. Neither is the arrangement of the materials conformable to what is observed in natural deposits, where there is always more or less stratification and sorting, according to the volume and weight.

On examining more closely these heaps of shells, it was not long before there were discovered in them broken bones of various wild

<sup>1</sup> This agrees perfectly with the testimony of statistics. (See “*Quetelet sur l'homme et le développement de ses facultés.*” Paris, 1835, vol. ii, p. 271. This work of first-rate merit is very near akin to *Archæology*. M. Quetelet has just published a new work, which will certainly be even more remarkable than the first, and which the author of the present paper regrets not to have had within his reach.

animals, and among these the bones of some species now extinct; then there were splinters of silex, (flint or quartz,) with roughly fashioned instruments of the same material, very coarse pottery, charcoal, and cinders.

At the same time most extensive excavations and most minute investigations established the fact that there was in these heaps a complete absence of any metal, whether iron or even bronze, as well as of any kind of domestic animal, except the dog. Here was then unmistakably the refuse of repasts, lying confusedly mingled with the remnants of the primitive mechanical inventions of a people that had resorted to the sea-shore in the most remote antiquity, living on fish and game. These remnants and refuse, accumulated in one spot<sup>1</sup> during a long series of centuries, have been called by the Danes **Kjoekkenmoedding**, from *Kjoekken* kitchen and *Moedding*<sup>2</sup> refuse, rubbish, filth.

The *Kjoekkenmoedding*<sup>3</sup> are invested with peculiar interest, because their nature excludes the presence of any object of a posterior date. Unless the soil should have been disturbed subsequently, which is always easily ascertainable, and which, on many spots that are now very distant from habitations, never has happened, we are sure that all that is drawn from these deposits does most certainly belong to high antiquity, and has not been brought there at a later time. The *Kjoekkenmoedding* are therefore real zoological museums of the animal kingdom, of the fauna, which man found on arriving in the country, and they thus form a link which binds the geological past of our globe with the present historical period. It is for this reason that the Danish savans have, for the last ten years, since 1847, set themselves to investigate the deposits in question with a spirit of research that does them the greatest honor, and which has not failed to lead to results of singular interest. And yet the subject in itself might appear to be somewhat trifling to those who do not consider that everything in this world is susceptible of being dignified by true genius.

In order that the question might be mastered under every aspect, it was attacked by the united forces of an association very fortunately composed of Mr. Forchhammer, the father of the geology of Denmark, of Mr. Worsaae, one of the greatest archeological celebrities of the north, and of Mr. Steenstrup, a zoologist and botanist, well known to all those who take an interest in the great and curious question of alternating generation and in the no less important one of the formation of turf-bogs.

These gentlemen, all of them professors in the University of Copenhagen, have published six annual reports of their researches, (from 1850 to 1856,) addressed to the Academy of Sciences of Copenhagen, and signed collectively by all three. They have also gathered little

<sup>1</sup>Sea shell-fish supply an enormous quantity of refuse, for the very simple reason that the animals are small and their casing is solid and spacious.

<sup>2</sup>This term is found in Yorkshire, England, under the form of *midding*, and with exactly the same meaning.

<sup>3</sup>The plural in Danish is *Kjoekkenmoeddinge*. We have retained the singular. In the present memoir all the foreign terms are preserved without alteration in the singular number.

by little a collection which contains, among other things, some ten thousand specimens of bones, each of which is labelled according to where it was found; this having been determined most carefully. Finally, with a select portion of these materials they have formed in the Museum of Antiquities of the North the admirable creation of Mr. Thomsen, a representation of the *Kjoekkenmoedding*, interesting on account of its size and the judgment with which it has been arranged.

Let us now enter upon the details of their researches :

**Geographical Distribution.**—The *Kjoekkenmoedding* have been observed in Seeland, especially along the Isefjord, in the isle of Fyen, of Moen, and Samsoe, also in Jutland, along the Liimfjord, the Maria-gerfjord, the Randersfjord, the Kolindsund, and the Horsenfjord. The more southern regions of Denmark have not yet been explored.

The *Kjoekkenmoedding* are scarcely found anywhere but along the fjords and arms of the sea, in places where the action of the waves has little power. Along the shore of the open sea, where the waves waste away, and little by little encroach upon the banks, there are none found. Now, as they must necessarily have also existed there, we may conclude therefore that in such localities there must have been a general encroachment of the sea on the land. There would be nothing surprising in this, for Denmark being composed in great part of very movable ground, which is but slightly elevated above the level of the sea, the action of the waves washes it away and easily eats into the shores.

Ordinarily the *Kjoekkenmoedding* are situated immediately on the edge of the water. At certain points, however, they are met with at as great a distance as two geographical miles from the present shore, but in such cases it can be proved that the dry land has made an inroad on the sea, either by sand and mud banks, or by the encroachment of turf formations. The shells have never been carried inland to any distance from the ancient shore line.

As regards the elevation at which the *Kjoekkenmoedding* are situated, it is to be remarked that on the shores of Denmark, although so low, they are nevertheless found out of reach of the action of the waves in rough weather; say at some ten feet at least above the present level of the sea.<sup>1</sup> When the shore is higher the *Kjoekkenmoedding* are found also at a greater elevation.

It is evident that deposits corresponding to the *Kjoekkenmoedding* will be found in a great many countries. Thus, M. Bruzelius, conservator of the Museum of Antiquities of Lund, has just found something similar on the coast of Sweden, near Kullaberg, in Scania.

M. Forel de Morges has discovered on the edge of the sea, near Mentona, (Gulf of Genoa,) certain caves with deposits containing quantities of shells of edible species, broken bones of animals, charcoal, and splinters of flint, fashioned precisely like those in the north.<sup>2</sup> Here, then, are *Kjoekkenmoedding* of the age of stone, just as

<sup>1</sup>A Danish foot is 0.31376 metres.

<sup>2</sup>The grottoes and caverns have usually been inhabited in high antiquity. They therefore deserve special attention from archaeologists.

in the north.<sup>1</sup> This discovery is all the more interesting from the fact that it has been some times denied that the south had its age of stone, because the Greek and Roman classic writers do not speak of it. As if a child could relate what had happened previous to its birth!

Lastly, Lyell, Darwin, and others have pointed out deposits of this kind, due to the habits of savage tribes on the shores of North America, on the coast of Newfoundland, and elsewhere.<sup>2</sup>

**Conformation**—The *Kjoekkenmoedding* present generally a thickness of from three to five feet. There are, however, points, as at Meilgaard and at Kolindsund, where the thickness of the mass attains ten feet. Their extent varies, it reaches sometimes to a thousand feet in length, with an irregular width, never exceeding from one hundred and fifty to two hundred feet. In the case of these great deposits we perceive that their surface is undulating, the mass having accumulated more at certain points than at others. Occasionally, as at the mill of Havelse, near Frederikssund, the deposit surrounds irregularly a space which has remained free and wherein was evidently situated the habitation of the shell-fish eaters. If no traces of these habitations have been left, it cannot be astonishing, for they must have been very wretched huts.

The interior of the deposits alluded to presents no sign of stratification. We remark merely at certain points the predominance of certain species of shells, indicating the particular circumstances of season and fishery. Thus there are found thousands of cockles (*Cardium*) piled up in one place, to the exclusion of every other species.

What has been said relates to the normal type of the *Kjoekkenmoedding*, when the materials have been accumulated on the very locality of habitation. Apart from these points, others are found, situated on the shore and within the field of action of the waves, where the usual materials of the *Kjoekkenmoedding* are mingled with sand and gravel, and where the whole mass is more or less clearly stratified, of which we may see a classical example at Biliat, near Frederikssund. It is evident that at these places the ancients cooked their meals on the very beach, after leaving their boats. The various fragments which they left were subsequently rearranged by the next heavy sea, which rolled the materials about and mingled them with the composition of the coast deposits. We can understand then how the fire places, composed of pebbles of the size of a man's fist, have resisted the action of the waves and have remained in their place, whilst the smaller materials have been rolled along with the sand and gravel.

A very singular circumstance is that the *Kjoekkenmoedding*, formed beyond the reach of the waves, present sometimes at their surface a deposit of slight thickness composed of rolled and stratified materials. But this is only observed up to a height of from fourteen to eighteen feet above the present level of the sea, and solely on the counter-slope of the ground turned towards the sea. At Oestetild, in northern Jut-

<sup>1</sup> Mr. Steenstrup, who has examined the collection deposited by Mr. Forel in the Museum of Turin, finds this correspondence complete, only he has not been able to find any marks of knives on the bones, which are however split and opened for the extraction of the marrow, as in the north.

<sup>2</sup> Lyell. A second visit to the United States of America. London, 1850; I., 338; II., 106, 135. Charles Darwin, Journal of Researches. London, 1840; 228.

land, this stratified coating attains a thickness of one foot and contains pebbles that are occasionally as large as a goose-egg. Above this stratified layer nothing more is found, it is never covered over by new accumulations of shells. It would seem then, that the age of the *Kjoekkenmoedding* was ended by some catastrophe which violently agitated the waters of the sea, and that the latter then rushed in at a moderate height beyond its habitual boundary.

It is just possible that this event might have occurred at any epoch posterior to the age of the *Kjoekkenmoedding*. Nevertheless Mr. Steenstrup is disposed to consider it as marking the very end of that age.

**Flora of the Kjoekkenmoedding.**—Of the vegetable kingdom there is left but few determinable remains. Charcoal and ashes are found in abundance in them. The charred vegetable matters have been gathered together, in order to determine to what species they belong, but this investigation is not yet concluded.

It is worthy of notice that there has been found in the *Kjoekkenmoedding* neither carbonized wheat nor a trace of any cereal whatsoever.

There are observed sometimes, not so much in the mass itself of the *Kjoekkenmoedding*, as in the soil adjoining them, deposits oftentimes rather considerable of a dark and pulverulent matter, resulting evidently from the carbonization of vegetable substances, which, however, were not wood, and which appear to have had their lye extracted. Chemical analysis revealed the existence of a large proportion of manganese in them, which, according to the researches of Mr. Forchhammer, is also found in pretty large quantities in the *eel-grass*, (*Zostera marina*, L.) Now, it is scarcely two hundred years since the eel-grass was employed for making salt. This vegetable was gathered into heaps, which were set on fire, the remains were then sprinkled with sea-water, and on the surface were formed saline efflorescences, which were collected. The product was a salt that was tolerably good, and which people must have been very glad to obtain when there was no other to be had. It seems, then, that the primitive population of Denmark were in the habit of manufacturing salt by the incineration of the eel-grass.

**Fauna of the Kjoekkenmoedding.**—The four species of shells, of which the greater part of the deposits in question are compounded, are:

The Oyster, (*Ostrea edulis*, L.)

The Cockle, (*Cardium edule*, L.)

The Muscle, (*Mytilus edulis*, L.)

The Littorine, (*Littorina littorea*, L.)

These four species, referred to here in the order of their frequency, are all represented by specimens generally large and of vigorous development. The oyster, which is the most abundant species in the *Kjoekkenmoedding*, and which often composes them almost entirely, has now disappeared from all the region situated farther in the interior than the Kattegat, and more southerly than the northern shore-line of Seeland. In the Kattegat itself we meet here and there with isolated living oysters. But there is one point only, that between the island of Laesse and the northern extremity of Jutland, where

an oyster bed has been regularly worked. It is from this that the city of Copenhagen is partly supplied. At the beginning of this century some oysters were procured at the entrance of the Isefjord, now they are no longer known in that locality,<sup>1</sup> and, as a matter of course, none are to be found in the innermost parts of the Isefjord. And yet in ancient times oysters abounded there and even throughout its whole extent. The fishing business may have contributed to cause the decrease in the quantity of oysters, but it could never have made them disappear entirely. Besides, the presence in the Isefjord of beds of dead oysters *in situ* plainly proves that it is not the fishery that has destroyed them. Their disappearance in the localities alluded to must therefore be attributed to a diminution of the saltness of the water, which must have become slightly fresher since the ancient times.

This observation is confirmed by what is remarked concerning the cockles and littorines. These two species are still found ordinarily living in the neighborhood of the *Kjoekkenmoedding*, in the inner part of the Kattegat; but they are at present smaller, and do not attain the vigorous development that they did in the old times in this vicinity.

The four species of shell-fish mentioned are all edible and are still used as food by mankind. They make their appearance, for example, in the London markets. The oyster is, however, by far the best; there is scarcely any other which is admitted to the table of the wealthy.

In addition to the four species referred, some others make their appearance, but only as exceptions, in the *Kjoekkenmoedding*, undoubtedly because as food they are very inferior in quality, and also because they are less abundant in the Danish waters. They are:

*Buccinum reticulatum*, L.<sup>2</sup>

*Buccinum undatum*, L.

*Venus palustra*, Mont.

As regards the *crustacea* there are but few remains of crabs found. The remains of fish, on the other hand, are in great quantity.

The herring (*Clupea harengus*, L.) is the most common, but the following species are not rare:

The Cod-fish, (*Gadus callarias*, L.)

The Flounder, (*Pleuronectes limanda*, L.)

The Eel, (*Muraena anguilla*, L.)

The abundance of these remains of fish proves that the primitive population used to fish in the open sea. And yet their craft could scarcely have been anything more than canoes, formed of trunks of trees scooped out by the aid of fire. One thing is certain, the shell-fish, especially the oysters, could only have been procured by fishing for them in boats, for the sea does not throw them up alive on the shore.

With reference to the eels, it is rather interesting to remark, that their ancient remains abound especially in the localities in which the

<sup>1</sup> It is well however to remark, that at this point it was a great numerical increase of the star-fish, (*Asterias rubens*, L.) which brought about at the commencement of the present century the destruction of the last generations of oysters.

<sup>2</sup> *Buccinum nassa*.



species still delights at the present day, as in the neighborhood of Aalborg.

Among the birds, it is the aquatic and palustrine species that abound. We meet especially with several kinds of ducks and wild geese.

The presence of the wild swan (*Anas cygnus*) proves, that the *Kjoekkenmoedding* were also in process of formation during the winter, for it is only in winter that this bird makes its appearance in Denmark. On the approach of spring it returns to the more northern regions. It is then, especially, that is heard its harmonious song, partaking of the sound of distant bells and of the eolian harp, whence, doubtless, the myth of its death chaunt.

The wood grouse (*Tetrao urogallus*, L.) is represented by large individuals of vigorous development. We see that the species thrive in those countries; but as it feeds chiefly on pine buds, it follows, that in old times the sea-shore was clothed with pine forests, whilst now-a-days these trees no longer grow naturally in Denmark. We will revert again to this subject, when speaking of peat-bogs.

A species which it was very surprising to find in the *Kjoekkenmoedding*, and which it was very difficult to identify, for the reason that museums contain only their skins stuffed with straw, without any skeleton, was the *Great Penguin*, of Buffon, (*Alca impennis*, L.) This bird, about the size of a goose, was totally incapable of flying, having nothing but the most diminutive apologies for wings or arms unfurnished with feathers suitable for flight. It frequented consequently only the small islands where there were no carnivorous animals. In the middle ages the great penguin was found in the islands near the coasts of Newfoundland and Cape Cod, in the United States, then in the islands near the southern shores of Iceland, in the Feroe islands, and at St. Kilda, to the west of the Hebrides. In old narratives and voyages to the Feroe islands we read, that the inhabitants of those regions were in the habit of eviscerating a penguin, thrusting a wick into the cavity of its stomach, setting fire to it, and letting this singular apparatus burn as if it were a lamp, so very fat and oily was the bird. On a little island near the coast of Newfoundland they burned these birds, for want of other fuel, as if they were logs of wood, and in this way they cooked one individual by the help of his companion. The species was so abundant on the islands of the coast of America that navigators very frequently calculated upon them as a fresh supply when their provisions were exhausted in a long passage. Whole boatloads were frequently brought on board. It has, nevertheless, also happened, that certain ships' crews, not meeting with the expected birds, have been driven to eat each other. This species, which was so numerous not very long ago, and of which we still possess a few stuffed specimens in museums, appears now to be completely destroyed and extinct, thanks to the omnivorous intervention of man. It was surmised that it might still be found on a small island to the southwest of Iceland; which is an almost inaccessible rock on account of the breakers. But an expedition that has just been undertaken by Mr. Wolley, to ascertain whether this was so, has not been able to find the lost bird. It is true that Temminck says in his great work on birds, and his words are often repeated by others, that the great penguin is common in Greenland;

but the Danes, who are pretty well acquainted in that region, know nothing about it.<sup>1</sup>

Our domestic fowl (*Gallus domesticus*) has not been found in the *Kjoekkenmoedding*. The well established absence of the two kinds of swallows, inhabiting now-a-days the constructions of men in Denmark, the chimney swallow (*Hirundo rustica*, L.) and the window swallow, (*Hirundo urbica*, L.) and then again that of the sparrow (*Fringilla domestica*, L.) and the stork, (*Ciconia alba*, Bel.) is nothing very surprising.

The quadrupeds, whose remains are most numerous, are :

The Deer, (*Cervus elaphus*, L.)

The Roe-buck, (*Cervus capreolus*, L.)

The Wild-boar, (*Sus scrofa*, L.)

These three species are no where deficient; they constituted evidently the principal food of the primitive population as regards land animals.

The Urus, (*Bos urus* or *primigenius*),

The Beaver, (*Castor fiber*, L.) and

The Phoca, (*Phoca gryphus*, Fab.)

are likewise species often met with, and which have constantly served for food to the primitive population. Now, the beaver has entirely disappeared from Denmark, the phoca is still seen in the Kattegat, though very rarely, and the *Urus* is an extinct species. Speaking of the latter, it will not be amiss to enter into some details respecting the genus *Bos*, for species are often confounded. Many persons think, for example, that the wild ox of Lithuania is the *Urus*, whereas it is the bison. Setting aside the decidedly fossil oxen, we distinguish the following species :

1°. *Bos primigenius*, (Boj.) *Bos urus*, (Nilsson.) *Bos primigenius*, (Owen.) Thur, Ur, and Urochs, according to the Germans. A species now extinct, but which must have still been in existence in Switzerland in the tenth century of our era, for it figures among the number of viands that appeared in those days at the table of the monks of St. Gall. The manuscript<sup>2</sup> mentions the *Urus*, the *Wisent*, and a wild ox which seems to have been simply the offspring of the domestic ox gone back to the wild state, and which, according to Tschudi,<sup>3</sup> was still hunted in the sixteenth century.

2°. *Bos bison*, (Auct.) *Urus nostras*, (Boj.) *Bison europæus*, (Leidy.) Aurox, so called by the French. The *Wisent* and *Bison* of the Germans and the *Zuhr* of the Poles, *Bonasmus* of the ancients. A species

<sup>1</sup> Mr. Steenstrup has published a whole treatise on the great penguin in the scientific communications of the Natural History Assemblies of Copenhagen, 1855.

<sup>2</sup> *Benedictiones ad mensas Ekkeharde monachi Sangallensis*. Memoirs of the Society of the Antiquaries of Zurich, vol. III. Here is the passage in question :

Signet uestontem benedictio cornipotentem  
 Dextra dei ueri comes assit carnibus uri  
 Sit bos siluanus sub trino nomine sanus.  
 Sit feralis equi caro dulcis in hac cruce Christi.

However *veson cornipotens* and *urus* may here be nothing more than synonyms of the same species. That is, at least, the opinion of Mr. Steenstrup.

<sup>3</sup> *Tschudi*. The Alps. Berne, 1859.

formerly spread all over Europe; no longer found at present except in the forest of Bialowice in Lithuania, where there exists a herd of some seven or eight hundred head, which owes its preservation to the ukases of the Emperors of Russia.

The skeleton of the *urus* is more thick set, squat, and much stronger. His atlas attains the enormous width of twenty-seven centimetres—10.63 inches, (Museum of Lund.) The *bison* is more slender, he is moreover furnished with thick fur and a strong mane, which appear to have been wanting in the *urus*, judging from what the ancients say.

3°. *Bos frontosus*, (Nilsson.)<sup>1</sup> Appears to have existed in Denmark only in the domestic state, during the age of bronze and the first part of the age of iron, until about the commencement of the Christian era. There are extensive remains of them in the peat-bogs of Denmark. This species is distinguished from the others by the manner in which the horns are fixed on a lateral protuberance of the skull, and by the gibbosity of the occiput.

4°. *Bos taurus*, (L.) Corresponds probably to the *Bos longifrons* of Owen. It is the most generally diffused species, as a domestic race, in the middle ages and at present. Only it attains a more vigorous development than formerly. The wild ox of the park of Hamilton, in Scotland, (*white urus*.) is the same species, but in a wild state.

The four species mentioned above present not only differences of race, they are really distinct species. It is only the first, the *urus* proper, which has been found in the *Kjoekkenmoedding*. The second, the *bison*, is missing, but is found, though rarely, in the peat deposits of Denmark.

The elk (*Cervus alces*, L.) and the rein-deer (*Cervus tarandus*, L.) have not yet been discovered in the *Kjoekkenmoedding*. They will doubtless be found therein, for their bones have been gathered among the remains of the stone-age in Denmark.

There are also found in the *Kjoekkenmoedding*:

The Wolf, (*Canis lupus*, L.)

The Fox, (*Canis vulpes*, L.)

The Lynx, (*Felis lynx*, L.)

The Wild-cat, (*Felis catus*, L.)

The Sable, (*Mustela martes*, L.) and

The Otter, (*Lutra vulgaris*, Erxl.)

These species are found more rarely than the preceding ones; they have, however, served as food to man.

The hedge-hog (*Erinaceus europæus*, L.) and the water-rat (*Hypudæus amphibius*, L.) have been found accidentally in the *Kjoekkenmoedding*, where they also find bones gnawed by these rats.

Not the slightest trace has been found of the hare (*Lepus timidus*) in the *Kjoekkenmoedding*. But this can be accounted for when we reflect that the Laplanders and several other nations have a sort of superstitious repugnance for the hare, and would not eat it except when driven to do so by the utmost extremity of famine.

According to what has already been stated, the *Kjoekkenmoedding* have furnished no domestic animal whatsoever except the dog. And

<sup>1</sup> Nilsson. Scandinavisk fauna, II edit., Lund., 1847, p. 555.

even with respect to that, it could not be ascertained *a priori*, whether the bones of the dogs which were found had belonged to a domestic or a wild race. The following is the way in which they have been able to solve the question indirectly.

It was surprising not to find, among the exuvia of birds any but the middle part of the long bones, the heads having been broken off very irregularly. Whilst, numerically, the long bones form very nearly the fifth part of the sum total of the bones of a bird, they are in the *Kjoekkenmoedding* from twenty to twenty-five times more numerous than the other. Whence comes this singular preponderance of the long bones? It was thought at first that the ancients had consumed on the spot merely the limbs of the birds, reserving the carcasses for a stock of provisions at sea. This was rather far-fetched. Mr. Steenstrup bethought himself of keeping some dogs in confinement, and giving them for a certain time birds to eat. He then found that all that the dogs left were the same long bones, such as the *Kjoekkenmoedding* present. All the rest had been devoured. Some other carnivorous animal, such as the wolf or the fox, might, it is true, have done the same, although the wolf, for example, generally drags off his prey, and does not devour it on the spot. But as these numerous fragments of birds, thus gnawed, are found everywhere, in all the *Kjoekkenmoedding* that have been examined and in every part of each of these deposits,<sup>1</sup> it follows, that the people were accompanied by a domestic carnivorous animal, which is only represented by the dog. This induction is confirmed by the abundance of gnawed bones of quadrupeds. Nearly all the cartilaginous and more or less soft parts of the bones have been irregularly subtracted. Often the marks of the teeth that have gnawed the bone, are sharply defined. Thus one rarely finds a shoulder-blade that has not been gnawed, or a rib whose extremities are entire.

The marks of knives which Mr. Steenstrup observed on the bones of the dog, led him to conclude that the primitive population ate this animal, as is still done in many parts of the globe, in America, Oceania, Africa, and, as it would appear, even in Europe. Mr. Forel de Morges has asserted that in the Riviera of Genoa they eat dogs, and that rats are considered a delicacy there.

They have not yet found in the *Kjoekkenmoedding* any traces of those young aquatic birds, which are taken in their nests, and of which there is at present a great consumption, in Jutland, for example. It is a dish in great request, and very abundant in certain localities; and there are some islets, perfectly barren in other respects, where the right to collect eggs and young birds produces a very handsome income. We might have been tempted to conclude from the absence of the remains of young birds, that the primitive population absented itself from the localities of the *Kjoekkenmoedding* from the month of May to August. But it is more likely that the dogs caused the disappearance of the smallest traces of the young birds, inasmuch as they left merely the very hard middle part of the long bones of

<sup>1</sup> About forty have been examined minutely.

even the adult birds, the splinters of which threatened to choke them. Man himself came in doubtless for his share in the matter, for we know of certain persons even nowadays eating whole quails, without taking the trouble to separate the bones.

The sojourn of man on the *Kjoekkenmoedding* grounds during the autumn, winter, and spring is also indicated by the degree of growth of the horns of the deer and roe-buck, as well as of the embryos and young individuals of these species and of the wild hog, which have been eaten and whose remains are met with. Here again the summer season is not clearly marked, but as the primitive population dwelt on the seashore in winter, according to what we have seen, when speaking of the wild swan, it is very likely that it spent the fine season there also, during which it must have been much more comfortable in every respect.

**Man and the products of his Industry.**—The *Kjoekkenmoedding* have never presented any human bones. One may possibly meet with skeletons there, but in that case they belong to those graves, often of very recent date, which the inhabitant of the coast digs for the body of the shipwrecked individual that has been cast up by the sea. No ancient burial place of the age of stone has ever been observed there, and we understand in effect, that the primitive population would not bury its dead in such places. Besides, the numerous tombs of the age of stone in Denmark bear witness, by their often gigantic proportions, as also by their contents, to the respect in which the dead were held.

It is here worthy of remark, that there has never been observed in Denmark, either in the *Kjoekkenmoedding* or elsewhere, any signs of cannibalism, though an antiquary supposed that he had found such signs in a cavern in Belgium.<sup>1</sup> If his observations were of value, we might expect that same fact would be observed in other parts of Europe.

There are sometimes found in the internal mass of the non-stratified *Kjoekkenmoedding*, as there are in the stratified deposits of the seashore, fire-places simply formed of a pavement of pebbles about the size of a man's fist. When we can obtain a quite fresh and clean section of a non-stratified deposit, we sometimes observe on each side of the fire-place a little black band, gradually becoming less distinct. This is made by the coal, which had been swept away when a new fire had to be lighted. These fire-places are not large, they are more or less circular, and their diameter is somewhere about two feet.

Fragments of a very coarse pottery are not scarce. The vases have been molded by hand, and not by a lathe, and the clay has always been mixed with sand, evidently in order that the vases should not crack easily in the fire. This device is still resorted to by certain savage tribes of America; we find them even, when they cannot get sand, substituting for this purpose a powder of ground-shells. One fact had struck the Danish archæologists, namely: that the grains of sand imbedded in this pottery are angular, whilst no sand is found in the country but what is rounded by the action of the waves. They then

<sup>1</sup> Royal Academy of Belgium, Tome XX, Nos. 11, 12.

remarked that the granitic stones of the fire-places, when they had been subjected to the action of fire, were easily reducible to coarse angular sand, corresponding exactly to that found in the pottery.

Mr. Emilien Dumas de Sommières, (department du Gard,) a much-esteemed geologist, and a great connoisseur in pottery, has observed a very great diversity of materials mixed with the paste of the ancient pottery. These substances seem to vary according to the mineralogical character of the region. Thus it is that in the departments of the Gard, Vaucluse, and Bouches-du-Rhone, the ancient pottery contains generally little rhomboidal fragments of white spathic carbonate of lime. In Auvergne, in the Vivarais, and even at Agde, near Montpellier, where there exist also ancient traces of volcanic eruptions, the place of calcareous spar is supplied in the ancient pottery by volcanic scoria (*peperino*.) Lastly, in Corsica, a few years since, they made use of amianthus in the manufacture of common pottery, which gave it great toughness and tenacity, and enabled it to resist most efficaciously the effects of a blow or of irregular dilatation. Amianthus is also found mingled with the paste of some Chinese vases of common manufacture. It is likewise known that the walls of Babylon and certain constructions of ancient Egypt were built of bricks dried in the sun. In making these bricks they added to the sandy clay which composes them, chopped straw, and even fragments of reeds and other marsh plants, in order to produce greater strength in the mass. Besides, this necessity for the addition of straw is well-established by the fifth chapter of Exodus, which alludes to the refusal of the king of Egypt to furnish the Israelites with the straw required for their work.

The age of stone, as we know, is characterized preëminently by the presence of arms and instruments of flint, or of some other kind of stone, and which are frequently of beautiful workmanship, especially in the islands of Denmark. Now, in the *Kjoekkenmoedding*, it is true that there are found a great abundance of instruments of silex, but they are so very rough and unshapely, that one might take them at a first glance for mere pieces of stone. Nevertheless, with a little attention and comparison it becomes easy to recognize them as wedges or hatchets, chisels, and especially those long and narrow splinters called knives. All these objects are simply hewn by hand, by successive blows with another stone; they are of coarser workmanship than



Fig. 4.



Fig. 5.

Very rough wedges.



Fig. 6.

Chip.

many objects of flint found elsewhere, especially in the tombs. This has caused it to be believed that the *Kjoekkenmoedding* might belong to a first age of stone, which should be distinguished from a second one, to which ought to be attributed the handsome specimens so frequently found in the North, and which bear witness to a general progress of civilization. It is possible that this is really the case, but there is as yet no decisive reason in favor of this opinion. If none but very rough objects are found in the *Kjoekkenmoedding*, it is not very strange; since in ancient times, any more than now-a-days, would people be likely to scatter objects of value among their sweepings, and we should, therefore, merely find the refuse of their industry. Notwithstanding, there have really been found in the *Kjoekkenmoedding* some rare specimens of fine workmanship. They are, a lance-head of silex, an arrow-head of silex, and a little hatchet of trap (volcanic rock) of regular shape and nicely bored, all which would certainly not indicate an industry just at its origin. Finally, the bones of the animals which have served as food to the primitive population bear positive witness to the use of well made instruments. They (the bones) have been jagged and chipped in divers ways, either when the animal was being cut up or when portions of it were being eaten, and the flesh was separated by means of knives. Now, on examining attentively these marks, we recognize that the primitive population made use of well ground and keen-edged instruments, which have made incisions in the bone as clearly as a good steel knife would do. A simple splinter of flint, however sharp it may be, and supposing it not to be ground, will leave a mark bearing the character of the saw; that is to say, there will easily be seen in it, by the aid of a magnifying glass, a number of parallel striæ. Therefore, in the age of the *Kjoekkenmoedding* they had already instruments of silex of good workmanship, only they did not fling them away among the rubbish, but they took good care of them since they must have cost much more labor than our steel instruments.

Besides the rough instruments of silex, already spoken of, there are found in the *Kjoekkenmoedding* a tolerably large quantity of hewn pebbles, but in such a shapeless manner, that the workmen could evidently have had no other intention, when thus preparing them, than to give them sharp edges and angles. Now, if we reflect, that an angular pebble will wound much more severely than a round one, it becomes very probable that we are here presented with the offensive projectiles of the primitive population.

Pebbles cut in this way are frequently found in the turf-bogs of Denmark. They were probably thrown in old times, either by hand or by slings, at aquatic birds, and have since become inclosed by the turf in its process of formation in these localities. Let us remark lastly, that in the salt-works of Hallein, in Austria, there were found, together with a bronze hatchet, a little wallet of skin containing two projectiles like those above alluded to.<sup>1</sup>

The *Kjoekkenmoedding* furnish a tolerable quantity of ends of deer-

<sup>1</sup> These articles are preserved in the museum of Salsburg.

horns, which have been cut off and broken. It was naturally the refuse only which was thrown away, and so the pieces that were wrought and finished are missing. Nevertheless this refuse shows positively enough that well ground chisels of silex were used, and that they were managed with skill.

Carved bones have also been met with in the *Kjoekkenmoedding*. They were made into awls, chisels, and even a sort of comb very neatly fashioned, which appears to have been used in the manufacture of thongs from sinews.

A circumstance worthy of notice is, that all the solid bones, not hollow, of quadrupeds, are entire, whilst those which are hollow are found, almost without exception, broken, showing frequently the mark of the blow by which they were opened. The primitive people were evidently fond of marrow, which they extracted wherever they found it, either to eat it, or to employ it with brains in the preparation of skins, as is done by the savages of North America.<sup>1</sup> The hollow bones (*os metacarpi* and *metatarsi*) of ruminating animals, such as the deer and roe-buck, presenting a longitudinal partition, which separates more or less the marrow into two parts, have always been split transversely to this partition in the direction of their length. Thereby the two compartments of the marrow were laid open at one blow, and its immediate extraction was thus rendered easy. The same process is still in vogue among the Laplanders and the Greenlanders, with whom the marrow, still warm from the natural heat of the animal, is considered the greatest delicacy and a dish of honor, which they offer to strangers and to the employés of the government. The dexterity with which these people thus open the bones of the reindeer, is said to be surprising. It is to be noticed, however, that they split the hollow bones of the reindeer longitudinally, and parallel to the middle partition, which is very thin in this species.

Another circumstance affords its testimony to the practical sense of the primitive people of Denmark. It is that, for the fabrication of instruments and objects of bone, they have been clever enough to select and to profit by that portion of the skeleton of the animal whose structure offers the greatest density and strength, namely: that on the inner side of the radius.

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## II. PEAT-BOGS.

The *Kjoekkenmoedding* have furnished valuable data for the study of the ancient fauna of Denmark; but we have seen that they present very few resources for the study of the ancient flora of this country. What they are, however, in regard to the animal kingdom, the peat-bogs are to the vegetable kingdom. Mr. Steenstrup has made these the object

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<sup>1</sup> *Hearne*. Voyage du Fort du Prince de Galles a l'ocean Nord en 1769, 1772. Paris, vol. VII, p. 343. "The Indians prepare the skins with a lye made of brains and marrow."



of a special study, and that for about twenty years past.<sup>1</sup> The following are the principal results :

Denmark is very rich in peat, and we distinguish there several kinds of peat-bogs, according to circumstances of location, extent, and internal composition. They are :

1°. **The Kjaermose or Engmose**, of the Danes ; *Wiesenmoor*, of the Germans ; which may be translated by *bog-meadows*. This kind of bog occupies especially the bottoms of wide valleys, alongside of water courses and low grounds, often bordering on lakes. They are also disposed to take possession of the bottom of bays and shallow fjords, whence the sea then retires little by little. The *kjaermose* are formed principally of the remains of rushes and herbaceous plants, with but few mosses. They present in their formation *infra-aquatic* parts, and *supra-aquatic* or emerged parts. The first owe their origin to plants that grow at the bottom of the water. The *kjaermose* are generally of a less thickness than the other peat-bogs ; they are usually not more than from five to twelve feet deep.

2. **The Lyngmose, Svampmose, or Hoermose**, of the Danes ; *Heidmoor* or *Hochmoor*, of the Germans ; which may be translated *heather bogs*. They often occupy very extended planes, the surface of which is above the level of the sea. They are formed of decayed mosses, (*sphagnum* and *hypnum*,) and are covered with heather. These bogs are ordinarily from eight to ten and sometimes fourteen feet deep.

3°. The **Skovmose**, of the Danes ; which may be rendered by *Waldmoor* in German, and by *forest-bogs* in English.<sup>2</sup> They are the most interesting, and deserve to be discussed in detail.

The *Skovmose* occupy in the quaternary lands of Denmark singular depressions of rounded form and slight extent, when there are not several joined together, but of a depth that reaches to thirty feet or more. These quaternary lands are in a great part deposits of erratic origin, formed from compact glacial mud, inclosing pebbles and blocks of stone of Swedish origin. These latter are often polished and sharply striated, just as we frequently observe on the surface of the great blocks forming the sepulchral halls, in the interior of the tumuli of the age of stone. These abrupt depressions of the ground in such a soil are rather surprising and difficult to explain. There are some that owe perhaps their origin to the sinking in of the subjacent calcareous rocks. In his travels in Iceland, Mr. Steenstrup remarked that blocks of ice detached from the great glaciers became sometimes mixed up with the materials of the moraine, and then produced, when they are melted, depressions of the surface very analogous to those alluded to in Denmark.

The *Skovmose* display the following internal composition. As their edges were more or less precipitous, the trees that grew there, when they had become very large, ultimately lost their balance and

<sup>1</sup>The principal essay of Mr. Steenstrup on this subject is to be found in the Memoirs of the Academy of Sciences of Copenhagen, vol. IX, 1842. An excellent work in French on the same subject is : "Some Researches on the Peat-bogs," by L. Lesquereux. Neuchatel, 1844.

<sup>2</sup>*Skov* signifies forest, and *mose* marsh.

fell over into the bog, where they were thus preserved and accumulated. It was thought at first that this was caused merely by a gust of wind, but a more careful examination of a peat-bog brought to light the fact that along its whole circumference the trunks were laid more or less regularly towards the centre. Sometimes the *Skovmose* is so small that the trees cross it from side to side. Often the trunks have accumulated in such numbers that we might imagine them to be artificially and skillfully heaped up and interwoven in such a manner as to pack together the greatest possible number in the smallest space. When the bog is not small enough to be thus encumbered all over, its central portion is occupied by the peat formation properly so called. We have thus to distinguish in the *Skovmose* an *exterior woody zone* and an interior or central bog zone. The latter is formed in an identical manner with that of the *Lyngmose*, for these differ from the *Skovmose* merely by the absence of the exterior woody belt, which could not be formed on account of the edges being usually too flat and too little inclined in the *Lyngmose*. There is consequently a gradual transition from the *Lyngmose* to the *Skovmose*, and we may consider these latter as *Lyngmose* that are very contracted and deepened.

**Central Region of the *Skovmose*.**—Its composition is very regular. The foundation of the basin, occupied by the bog, is formed by an argillaceous layer, produced from the wash of the edges of the depression. Next above this comes a horizontal layer of from one and a half to two feet, in extreme cases of three to four feet, in thickness, of amorphous peat, forming a pulp with the water, and in which we can easily discover with the magnifying glass the presence of vegetable substances, but without being able to distinguish their species. In the normal peat-bogs the amorphous peat is very pure and without admixture of extraneous substances. But, according as the waters were charged with mineral matters; there have often been formed in this inferior stratum, siliceous deposits, composed of the shells of infusores, or else of deposits of calcareous tufa, or even also layers of an intermixture of the two matters. These deposits are the sediments of which the water clarified itself. Whilst they were settling, the formation of the peaty matter must have been more or less retarded, to recommence again vigorously at a later time, when the waters had become clearer.

To the amorphous peat succeeds a layer, usually from three to four feet thick, of a peat which it is easy to recognise as being composed of mosses, (*Hypnum*.) Then there appear sometimes trunks of pine (*Pinus sylvestris*), which have grown on the spot, and which have sometimes formed a forest on the swamp. But these pine trees are stunted, crooked, and with the rings of their growth (*Anneaux d'accroissement*) so very close together that seventy have been counted in one inch of thickness. We perceive that the locality was not propitious to them, and yet that did not prevent them from living for three or even four centuries. In the large swamps there are found as many as two and three layers one over the other of these pine trunks *in situ*, with their bases and roots well preserved.

As the ground became gradually higher and dryer by the growth of the bog, those species of mosses which had first made their appear-

ance gave place to others ; the bog-moss, (*Sphagnum*,) and finally the heather made its appearance. Firstly came the cranberry, (*Vaccinium oxycoccos*, L.,) the *Vaccinium uliginosum*, (L.,) and the *Erica tetralix*, (L.,) and lastly the *Erica vulgaris*, (L.) The arborescent vegetation of the pines then gave place to white birches, (*Betula alba*, L.,) and afterwards to alders, (*Alnus glutinosa*, L.,) and to hazel bushes, (*Corylus avellana*, L.)

This last stratum of the *Sphagnum* attains from three to ten feet thickness, according to circumstances. It concludes the formation of the *Skovmose*, the surface of which finally becomes more or less solid and firm.

As a matter of course, the complete development of all the strata spoken of can be observed only in the central region of the swamps, where the depth is sufficient. Towards the edges of the swamps, the formation is more compressed and restricted within narrower limits of thickness.

We do not yet possess any data respecting the time which has been required for these peat-bogs to reach their last stage of growth. Mr. Steenstrup estimates that in order to form one of these masses of peat ten or twenty feet thick it has required at least four thousand years, but he thinks that this may be only the third or the quarter of the necessary time.

It is often supposed that the formation of the peat is more or less rapid, because pits whence it has been extracted become filled up again in a more or less short period. Mr. Steenstrup sees in this phenomenon the effect, less of the growth of the turf, which is extremely slow, than of a filling up from below, by the hydrostatic pressure of the surrounding swamp. And, accordingly, the peat-bogs become altogether exhausted in the long run, as Denmark has actually experienced.

**Exterior Forest Zone of the Skovmose.**—Above the clayey deposit spoken of, which constitutes the basis of the basin containing the swamp, there appear, firstly, the recumbent trunks of the pine (*Pinus silvestris*) in great numbers. They attain a diameter of three feet, with a corresponding length, and their magnificent stature proves on one hand that they found conditions of existence favorable to their growth, and on the other that they grew very closely together, forming forests of pure species, unmixed with any others ; for when pine trees are not thus closely arranged they do not arrive at this straight and tall stature. The species certainly was the same as our present one, only the cones were on the average a little smaller, and the bark was thicker than at the present.

The presence of the pine in the peat-bogs of Denmark was the more surprising, that in our day the species has entirely disappeared from the country, the pines that are found there now having been introduced in modern times. This is so true, that no historical or even traditional data makes the slightest allusion to the pine, as having grown naturally in Denmark ; therefore, the species must have disappeared a very long time ago. As for the *firs* (*Pinus abies*) it never occurred spontaneously in Denmark, not even in ancient times. They have begun to plant it since the end of the last century.

We will state here that there are localities where the pine-trees of the exterior zone enter under and are partially covered over by an upper layer of pine-trees *in situ* belonging to the central bog region.

Ascending through the series of formations of the exterior zone of the *Skovmose*, we find that the pine trees gradually disappear and are replaced by oaks, which finally prevail exclusively. Here again the trees are of handsome stature, betokening a vigorous growth, for the trunks often reach a diameter of four feet. It is the *Quercus robur sessiflora* of Smith, the *Wintereiche* of the Germans, which is generally thus found in the *Skovmose*. As for the *Quercus pedunculata* of Ehrhard, *Sommereiche* of the Germans, that Koch and others consider as specifically different from the first, it has not yet been discovered in the lower portions of the *Skovmose*, whilst it makes its appearance in the upper layer together with the warty birch, the alder, and the filbert tree. Speaking of these two forms of oak it has been remarked, in Sweden, for instance, that the *Quercus robur* preferred uncultivated lands, and that it tended of its own accord to disappear and to give place to the peduncled oak when the soil became improved by a prolonged cultivation that increased the proportion of humus.

Now, the oak is in its turn in a fair way of disappearing from Denmark. Although it is still found here and there, especially in Jütland, in thinly peopled and uncultivated districts; it is, however, almost exclusively the peduncled oak which is thus met with. But the arborescent vegetation of Denmark produces now, in preference, the beech, (*Fagus silvatica*,) and that so luxuriantly, that Denmark is deservedly celebrated for its forests of beech, the finest, it is said, in the whole world.<sup>1</sup> The stranger will be struck no less with the beauty of the beech forests, especially on the pleasant shores of the Sound, than with the profound admiration of the Danes for this ornament of their interesting country.

If the oak has not entirely disappeared from Denmark, the beech has established a footing there a long while ago, as is testified by public opinion, which holds that the forests of beech are of the highest antiquity in the country. The beech is missing altogether in the *Skovmose*, even in their upper parts. We would not be justified in concluding from this that it did not exist in the country, for this particular locality, on the edge of the marshes, was no more suited to it anciently than it would be nowadays. But the presence alluded to of the wood-grouse in the *Kjoekkenmoedding* proves, that elsewhere also the pine prevailed in the highest antiquity.

We come then to the conclusion, *that there have been three distinct periods of arborescent vegetation in Denmark; a first period of the pine, a second period of the oak, and lastly a third period—still continuing—of the beech.*

What is the cause of these changes, which have evidently not been abrupt, but which have been brought about little by little, without the intervention of anything like a catastrophe or a cataclysm of nature?

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<sup>1</sup> See the Memoir of *Vaupell* on the invasion of the beech in the forests of Denmark. *Annals of the Natural Sciences*. Paris, 1857; tome VII., No. 1, 2.

The climate has scarcely changed since the first appearance of man in the country, for the terrestrial mollusk species, which are found accidentally in the *Kjoekkenmoedding*, and the fluviatile mollusks which are met with in greater number in the marly layers of the peat bogs, are without exception identical with the species living at present in the country, and we know what good climatometer snails are, (*helix*.) Our *vineyard snail* (*Helix pomatia*, L.) is missing in the antiquity of Denmark, while it is now found in the country; but it is known that it was introduced by the monks in the middle ages.

The succession of the pine, the oak, and the beech appears to be simply owing to a gradual desiccation of the soil and a gradual amelioration of the mould. For it is the pine that is satisfied with the most humid and least fertile soil, whilst the beech craves the driest and in general the best.

We may notice here that the aspen (*Populus tremula*, L.) traverses the whole of the turf epoch from its beginning, and that it still flourishes in the country. Not so with the *white birch*, (*Betula alba*, L.) which is found in the lower layers of the peat-bogs, where it is represented by large individuals of fine stature, but which give place in the upper layers to the *warty birch*, (*Betula verrucosa*, Ehr.) which flourishes still in Denmark.

**Archæology of the Peat-Bogs.**—The peat-bogs of Denmark swarm with antiquities of all kinds and of all ages, as the museums show. Mr. Steenstrup estimates that there is scarcely a vertical column a metre square at the base, and taken anywhere, in any peat-bog whatsoever in the country, in which at least one antique object may not be found. The traces of the presence of man cannot, however, be followed to the very bottom of the *Skovmose*, which are generally the most ancient of the peat-bogs, and the more ancient as they are less extensive but deeper. There are no antiquities in the amorphous peat, but traces of man appear early in the pine layer of the outer band of the *Skovmose*, and this establishes the high antiquity of the primitive population of Denmark. There have been found various objects of flint, characterizing the age of stone, in the pine layer; Mr. Steenstrup withdrew some with his own hand from beneath trunks. Among the trees of this layer they have remarked some that had been cut with the aid of fire, specimens of which are preserved in the museum of Copenhagen.

The pine had very nearly disappeared before the end of the age of stone in Denmark, for the indications of the latter are observable even in the oak-layer.

It is very possible that man himself may have contributed to cause the disappearance of the pine, for it was an easy wood to cut and pleasant to burn; moreover, the inner part of its bark, properly prepared, furnishes when boiled a very edible broth. The Laplanders are still quite fond of it. When they prepare a meal of it, they bark the tree all around up to a certain height. The tree then dies, and thus the routes of migration in Lapland are marked by a track of dead pines, which is continually widening. We can easily conceive how in a country, every part of which is so accessible as Denmark, the

pine might have diminished sensibly in this way, in consequence of the increase of the primitive population.

The decrease of the oak is also due, in some measure, to the progress of industry; this has been very apparent for the past four or five centuries, and especially during the present one.

The direct intervention of man would, however, not explain sufficiently the development of new species, and the fact of a gradual and natural change of the arborescent vegetation in Denmark is not the less an acquisition to science.

In connection with this it is somewhat interesting to state here the remark of a good observer: "The fir does not flourish at present in Denmark, it is always small and unhealthy, and it runs to waste in branches, the longest of which remain trailing on the ground. This gives it the shape of a cone with a wide base, which never rises above twenty-five or thirty feet. It is only in Sweden and Norway that the fir reassumes its height and beauty."<sup>1</sup>

As to the synchronological relations that may exist between the age of bronze and that of iron, on one hand, and the development of the arborescent vegetation of Denmark, on the other, there are not sufficient data to establish them. All that is known on this subject is, that the age of bronze must have commenced after the close of the age of the pine, and after the commencement of the age of the oak. It is also known that the epoch of the oak corresponds, at least partly, with this age, for there have been found articles of the age of bronze, such as the magnificent bronze bucklers of the museum of Copenhagen, in a *Kjaermose* connected with the age of the oak. Lastly, it is known that the historical age, including that of tradition, that is, the age of iron, belongs essentially to the epoch of the beech.

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### III. SUBJECT OF RACES.

The human races, which have followed each other in the course of ages, beginning with that primitive population, which accumulated the materials of the *Kjoekkenmoedding* on the shores of Denmark, are absorbing the attention of the scientific men of the North, antiquaries as well as naturalists. In the absence of all historical or even philological data, they have to turn towards natural history and set themselves to gather together the solid remains of the ancient populations, especially skulls, in order to arrive at the result by the method of comparison. This study has formed, for a number of years past, the speciality of the learned Professor Retzius, of Stockholm, and it is not neglected at Copenhagen. Much yet remains to be said on the subject, but the researches are still continued, and they begin to be full of light.

We are now in possession of good materials for the age of stone, for the primitive population of the North buried its dead in sepulchral

<sup>1</sup> Ch. v, Bonstetten. Scandinavia and the Alps. Geneva, 1826, page 70. Under the term of ordinary language, fir, the author probably means the pine of the botanists.

vaults, carefully constructed of large undressed blocks of stone, and it has been easy to collect a great many skulls, whose type could be decided on. They are small heads, remarkably rounded in every direction, but with a facial angle tolerably large, and a forehead which bears the stamp of an intellect not a little developed. This type reminds us of that of the Laplander, without our being able to affirm precisely that it is identical with it. We have yet to pursue the study of the Laplander, in order to know him better, and to see whether he may not have somewhat changed in the course of ages. Nevertheless, it cannot be denied that the aggregate of what is known tends to induce us consider the Laplanders as the last remnant, the descendants of the primitive population of Denmark, and probably of all the rest of Europe, for antique skulls of the same type have been discovered in France, in Ireland, and in Scotland.<sup>1</sup> On the other hand, the Laplander is considered, as it were, an extreme branch of the Mongol race; to which, therefore, the primitive population of the age of stone in Europe is likely to have belonged.

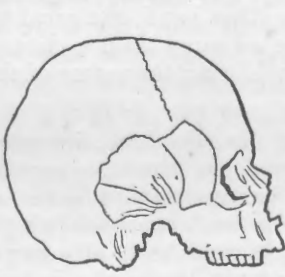


Fig. 7. (½)  
Type of the age of stone,  
Denmark.



Fig. 8. (½)  
A skull of the earliest times of the  
age of iron, Denmark.

If materials are not wanting to establish the type of the skull of the age of stone in Denmark, there is a great deficiency of them for the age of bronze, for the people of the age of bronze in the north usually burned their dead. But, as with the age of bronze we notice the apparition in Denmark of the domestic animals, the horse, the ox, the sheep, the goat, and the hog, we are thereby quite naturally led to believe in the irruption of a new flood of population, in the immigration of a new race, coming from the East.

With the introduction of iron, inhumation reappears in the north, but we are only beginning to collect the skulls of this epoch. Figure 8 represents one found at Sanderumgaard, in the island of Fyen. Here we are in presence of quite a different shape. The skull is remarkably elongated fore and aft, and the forehead is somewhat retreating. It is the form, though less decided, which predominates nowadays in Europe. It is also, according to Retzius, the long oval form, which is the so called Celtic type.

The human race of the age of stone, or in fewer words, the race of

<sup>1</sup> Retzius. Academy of Stockholm, 1847, No. 1.

stone, seems, in view of its analogies with the Laplander, to have been the most diminutive, and doubtless the weakest. We miss the bony framework of the race of the bronze epoch, but we have a measure of its hand in the handles of its swords, and we know how small are the proportions of these.<sup>1</sup> As the race of the bronze epoch evidently overcame that of the stone, and supplanted it, it is likely that it was superior to it, not only in the employment of metal, but also in the joint advantages of its civilization and its physical development. With iron there finally appears a large, strong race, as is denoted by the skeletons and arms. With the general progress of civilization, there has, therefore, been a progressive physical improvement of humanity.

People frequently marvel at the sight of certain gigantic works of antiquity, and they fancy that the ancient races must have been stronger than ours. But a little reflection will easily make us perceive the difference between the effects of patience, combined with skill, and the results of strength guided by knowledge; which, however, does not exclude either patience or skill. There are scarcely any ancient constructions of man, that are proportionally of greater magnitude, than certain ant hills. On the other hand, the great pyramid of Cheops is a wonder more likely to be admired than a chronometer, but in reality less astonishing, even considering the nature of the forces made use of in its execution.<sup>2</sup>

**Ancient Manner of Eating.** Let us describe here, *à propos* to the human race, an interesting peculiarity of the primitive population of Denmark. Modern nations use their incisive teeth to sever and cut as with scizzors. The front teeth lap over each other for this purpose, and there results necessarily a wearing of these teeth of a corresponding nature, and all the more easily recognizable as the individual is more advanced in life. Not only do the incisive teeth suffer from this manner of eating, but as in the region of the molars the two jaws correspond exactly with each other; that is to say, that the upper molars bear directly on the inferior ones, it follows hence, that the two jaws themselves cross each other at two points, namely, at the two angles of the mouth; whence a more or less irregular wearing away at these points. Now, when we examine attentively well-preserved sets of teeth of the age of stone in Denmark, that have belonged to individuals who have outlived at least the age of fifty, we find that the two jaws bear directly and wholly one on the other. The masticating surface of the upper jaw fits perfectly that of the lower jaw, and so all round the set of teeth. The incisive teeth do not lap over each other, but impinge on each other at their summits like the molars, and are, therefore, worn away quite differently from ours.<sup>3</sup> At the same time

<sup>1</sup>The same thing is observable nowadays among the Hindoos. The handle of their swords is too small for the hands of the English. *Pritchard*. The Natural History of Man, 1843, vol. I, p. 129.

<sup>2</sup>Consider the blast furnaces, tilt hammers, the rolling mills, with their accessories of steam and other engines, serving to prepare the materials and the instruments used by the watchmaker.

<sup>3</sup>There are exceptional persons who now use their teeth in the ancient way. Cuvier discovered the same mode of using the teeth among the ancient Egyptians. He says: "The incisive teeth of the mummies are all truncated, and with flat coronals." Comparative An-



the wearing away of the summits in the angles of the ancient jaws is more regular, and when we look straight along the surface of mastication, we perceive that the latter is an almost perfect plane. Therefore the primitive race ate in an entirely different manner from what we do; they used their incisive teeth, not to sever their victuals, as we do, but to seize them, to hold them, and to grind them. Thus we distinguish sometimes, according to what the individual had been eating last, striæ in a transverse direction to the axis of the mouth on the facets of mastication of the incisive teeth.

The Greenlanders, among the other people of the north, display the same peculiarity. When they eat flesh, after having disengaged it from the bone at one end, they seize it with the front teeth and tear it away partially; they then cut off the mouthful close to their lips by means of a knife. Even their children practice this method of eating with a dexterity which Europeans cannot imitate.

**Ancient Knives.** A circumstance, which is not without archæological importance, is that when eating and in general for the requirements of their industry, the Greenlanders do not use the knife with a longitudinal cutting edge like ours. Their knife is, properly speaking, a chisel, whose edge has a transverse direction, rather oblique to the longitudinal axis of the instrument.

This may explain why we find in the North so great a quantity of stone wedges or hatchets. These articles have not all served as hatchets, a great many were nothing more than knives of the Greenland pattern. So there are some not seldom found with an edge peculiarly curved, sometimes oblique. They are then rather generally cut away more or less to a point towards the other extremity, which rendered them decidedly unfitted for any handle, whilst they thus became more easily managed by the hand. They were evidently knives. There are some even that are clearly characterized as having been intended for the right hand. This is the case with the handsome specimen in Nephrite, Fig. 9; for, when taken hold of in the right hand with the



Fig. 9. (‡)  
Hatchet-knife of Nephrite.  
Moosseedorf.



Fig. 10. (‡)  
Hatchet intended for a handle.  
Switzerland.

atomy. Brussel's edition, 1838, vol. II, p. 105. The skulls of the Danish queens, Dagmar, deceased in 1216, and Beengjard, deceased in 1221, whose tombs were examined in 1855, show also this ancient use. See *Kongregavene i Ringstedkirke, Kjobenhavn*, 1858. There are anatomists who consider the irregular use of the teeth as an effect of the crossing of races in modern times; but, according to Mr. Steenstrup, this opinion is inadmissible.

obliquity of the cutting edge turned towards the person, the face A, which is then inwards, is found to be almost flat, whilst the opposite exterior face is much more convex. It would be the reverse if the instrument were held in the left hand, but keeping naturally the obliquity of the knife edge towards the person. We remark also that the instrument thus held suits the right hand much better than the left. It is therefore evident that this hatchet-knife has been made intentionally and with forethought to be used by the right hand.



Fig. 11. (†)  
Stone hatchet. Denmark.

Other wedges, with more prismatic forms, with straighter edges, terminated at the other end, not by a point, but by a surface perpendicular to the longitudinal axis of the piece, were evidently designed to be fitted with the handles, to be used as hatchets, properly speaking. Finally the stone hatchets, bored transversely for the introduction of a handle in the manner of our woodmen's axes, might possibly have been intended for some particular use, for they are found much more rarely than the others. We are, however, able to prove directly, that the knives of the age of stone were, at least partly, composed of these wedges; they are, with the exception of the chisels and gouges, the only instruments of flint with a cutting edge produced by the grindstone;<sup>1</sup> and we have seen that the marks of knives on the bones of the *Kjoekkenmoedding* came from instruments sharpened by grinding, which were, therefore, necessarily the wedges alluded to. The splinters of flint, usually called knives, appear to have served as saws.

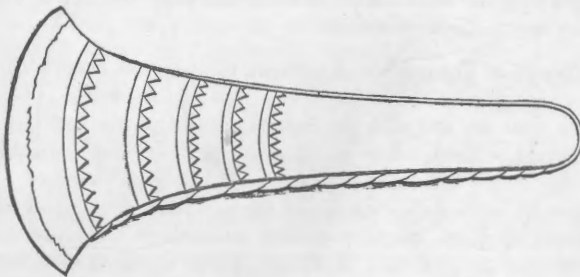


Fig. 12. (†)  
Hatchet-knife of bronze. Denmark.

. It would seem that the Greenland knife was still in use during the

<sup>1</sup>In high antiquity they were only acquainted merely with the fixed grindstone which is often found. The rotary grindstone only makes its appearance later.

age of bronze, for certain specimens, both from Italy and from Switzerland and the North, have something like winglets or very narrow flanges, which run along nearly the whole length of the haft; and the purpose of which has clearly been to render the latter more adaptable to the hand without any handle. We may also remark that the cutting edge presents a greater convexity, and it sometimes actually becomes a semicircle, which assimilates these specimens to the crescent-shaped knives of the saddler. The edges of the bronze hatchets, so called, are generally much less convex and straighter.

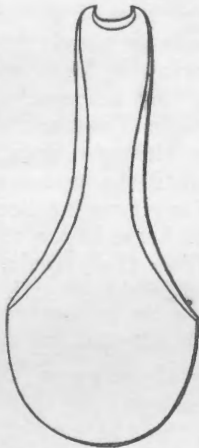


Fig. 13. (†)  
Bronze hatchet-knife.  
Switzerland.



Fig. 14. (†)  
(paalstab.)  
Bronze hatchets for handles.

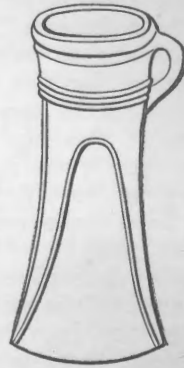


Fig. 15. (†)  
(celt.)  
Bronze hatchets for handles.

Nevertheless, in consequence of their weight and of the direction of their cutting edge, the Greenland shaped knives of stone and bronze could be used perfectly well for cutting, either like a knife, a chisel, or a hatchet. They constitute, therefore, an instrument which one might call a *hatchet-knife*, that must have been very effective, and which we do not have nowadays in use.

**The Subject of Domestic Animals** is of equal importance with that of the human races, and is scarcely less interesting. It is extremely remarkable that we are able to establish progressive physical improvement in animals that have been subjected to the influence of man. The *dog* affords us the most striking example of this.

In Denmark they have thought they could recognize three distinct types of races of dogs, corresponding to each of the three archæological ages. Now the canine race of stone is the weakest and the most puny of limb; the race of bronze is plainly stronger, but it is the race of iron that surpasses both the others.<sup>1</sup> The difference of the three races is, moreover, marked by the proportions of the *apophyse coronoide*. This bone is shorter in the dog of the stone age; it is sensibly longer in the dog of the bronze age, and still longer in the dog of the iron age.

<sup>1</sup> It is worthy of remark, that Indian dogs were renowned among the ancient Greeks.

The *sheep* was wanting in Denmark during the age of stone, and only makes its appearance with the bronze. But this sheep of the bronze age has limbs so very slender, that in determining it from certain bones, we would not suppose it to be of the same species as our present sheep.

It was known that the heaths of Jütland supported a race of very puny sheep. After three years' researches Mr. Steenstrup succeeded in obtaining a sample of them, but of which the race had undergone an increase of size. The bones of this sample are much more slender than those of the present sheep; they hold a middle place between the sheep of the bronze age and ours. The pure race of the heaths of Jütland appears not to have been in existence for nearly two centuries. There was no material interest in preserving it, for it was small, and its fleece furnished a coarse wool, and slight in amount.

The *domestic ox* only makes its appearance in Denmark with the age of bronze, but this ancient race was not as strong as ours.

Neither does the *horse* appear in Denmark until the bronze age, and the horse of this age is also smaller than our present horse. As would appear, it was somewhat late before the horse began to be used for riding, at least for warlike purposes. Thus the Greeks do not seem to have made use of cavalry until towards the seventh century before our era.<sup>1</sup>

The other domestic species, the *hog* and the *goat*, remain still to be investigated. It is merely known, as we have already seen, that they were introduced into Denmark with the bronze age.

In general there is not yet in Denmark, for the age of bronze, what the *Kjoekkenmoedding* furnish for the age of stone, namely: veritable well-arranged zoological museums, where we are sure to find nearly all the animals of the epoch brought together, without any mixture of any other fauna, either anterior or posterior. Nevertheless there have been already found at three points in the lowermost layers of the peat, on the edge of the *Kjaermose*, a considerable accumulation of bones, representing the fragments and refuse of meals, and belonging, judging from divers objects which accompany them, to the age of bronze. It is especially from these findings that the domestic animals of the age of bronze have been determined, and they are evidently the most ancient domestic animals of Denmark, except the dog.

By reference to Arabic documents, which the professor of Arabic, at Copenhagen, Mr. Meeren, has communicated to Mr. Steenstrup, the latter informs us that they began to tame the *cat* in the East towards the seventh century. It was not yet generally distributed there in the twelfth century, and it appears to have traveled into Europe shortly after, at that remarkable epoch when European civilization again received a powerful impulse from the East.

We frequently imagine that we discover the original stock of our domestic cat in the wild cat of Europe, but it is not the same species, although very nearly so, and rather difficult to distinguish by the skeleton. Connoisseurs, therefore, affirm that our wild cat does not cross with the domestic cat.

<sup>1</sup> *Minutoli*, Abhandungen Vermischten Inhaltes. Berlin, 1831, vol. I, p. 129.

## IV. PHYSICAL CHANGES.

The animal kingdom and the vegetable kingdom are not the only ones that have had their vicissitudes. Physical nature has also undergone sensible changes in the north.

**Denmark.**—We have seen that the geographical distribution of the *Kjoekkenmoedding* indicated an encroachment of the sea upon a large portion of the exterior shores, which have been eaten away and gradually swallowed up. This action appears to have been quite considerable in certain districts. We have seen that, on other points the *Kjoekkenmoedding* indicate an invasion of the domain of the waters by the dry land, either by embankments, beaches, or alluviums in general, or again by the encroachments of bog. These latter have been very considerable, both in the domain of the fresh waters and in that of the salt water, in the fjords, arms of the sea, and other low grounds of that kind.

It has thus been recognized that Jütland had been anciently traversed from end to end by many fjords and arms of the sea, which then made this region an archipelago, composed of numerous islands independent of each other. Nowadays there is only the Lümfjord, which traverses the country from the Kattegat to the North Sea, and even its mouth into the latter, the canal of Agger, is very narrow and shallow, allowing only small craft to enter; it even threatened to close up entirely in the spring of 1859.

Seeland also was cut up by fjords and arms of the sea. Thus, in the middle ages, they sailed up to Slangrup, which was then a sea-port. Now the arm of the sea is supplanted by a brook, running from Slangrup, along a distance of seven kilometers (four statute miles) before it enters the Isefjord, near Frederiksbund.

Tradition relates that a naval combat took place on the spot now occupied by Lake Tüs, in Seeland. The fleets must have come from the north and from the southwest, for this spot must then have formed part of a fjord that traversed from end to end the western region of Seeland. Nowadays Lake Tüs communicates with the sea merely by means of a brook. In this case, as in that of Slangrup, it is the peat-bogs that have brought about the change.

The great swamp called *Lille Vildmose*, situated at the eastern mouth of the Lümfjord, on the southern shore, has given occasion to a curious observation, recorded in the memoir already alluded to of Mr. Steenstrup on the peat-bogs. Its area must have formed anciently a marine flat, for dead oysters are found on it *in situ*. Later this flat was separated from the sea by a shore line which the latter threw up; this held back the out-flow of the waters and formed a lagune, where the peat gained ground so fast that the whole ended by being converted into a vast boggy, fresh-water marsh. In 1760 they bored through the shore line to enable the waters to escape, and thus to regain their former level. The area of a number of small lakes was thus drained dry, and it was found that these latter represented so many little ancient islands, on which the peat had not been able to get a footing, and which were now bounded all around their contour,

by a wall of peat from six to ten feet high. But what is the most curious is that there were found on these ancient islands burial-tumuli belonging to the age of bronze.

It is not only at this point that the formation of a shore-line by the action of the waves has been of some importance. It must have played a great part in the history of the changes of the soil in Denmark, particularly in Jütland, where it has combined to form the "downs."

**Decrease of the Saltness of the Sea.**—This we have seen proved as regards the interior waters of the Kattegat by the mollusks of the *Kjoekkenmoedding*. It may be owing to two different causes. First, to the fact that the communication between the Kattegat and the North sea has sensibly diminished by the accessions of land in Jütland, which were alluded to; but it may also be consequent upon the great mass of fresh water continually poured into the Baltic by the rivers, for there is no sea that has, in proportion to its size, so great an affluence of fresh water. This circumstance establishes a sensible difference between the sea-bathing outside and inside of the Sound. The further we go towards the interior of the Baltic, the more the saltness of the sea diminishes. Thus, at Rostock, it is no more than half of that of the North Sea at Aurich,<sup>1</sup> and at the bottom of the Gulf of Bothnia, it is scarcely brackish. In the Sound and in the Belt may be observed decided currents. In the Sound, which is the best known of these straits, there are on the average twelve days of current going out of the Baltic, for five days of current coming in. This excess is no doubt compensated for, partially at least, by the currents of the Great Belt. But it may be, that the efflux from the Baltic is so much greater than the influx, that in the long run the saltness of its waters becomes less and less.

It might be objected, that if this effect had made itself so sensible since the appearance of man in the north, the waters ought to have become much fresher during the later ante-human ages, so that the primitive population would already have found no oysters in the interior of the Kattegat. To this it may be answered, that formerly there was a communication between the White Sea and the Baltic, which was not closed long before the arrival of man.

**Level of the Land.**—The situation of the *Kjoekkenmoedding* proves that there has been no permanent change of any importance in the general elevation of the dry land in Denmark, since the coming of man. For if the non-stratified *Kjoekkenmoedding*, of which a great many descend only to ten feet above the present level of the sea, had formerly been a few feet lower, they would have been reached by the waves, during rough weather, and their interior would be partially stratified at these points. On the other hand, if the shore had been more elevated than nowadays the *Kjoekkenmoedding* on the shores, that have a stratified construction, could never have been reached by the waves.

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<sup>1</sup>The hydrological data are taken from the excellent work *Der Dänische Staat von A., v. Baggason. Copenhagen, 1845.*

The Danish savans are, however, disposed to admit a slight upheaving of the land, because at certain points, as, for instance, at Bilidt, near Frederikssund, the stratified *Kjoekkenmoedding* are now above the reach of the waves. But at Bilidt these layers are very near the present shore, and it might be that the sand-banks of the Isefjord had reduced the intensity of the motion of the sea. As to what concerns points outside of the Isefjord, it is necessary to consider what follows. At present the tide produces a difference of level of merely one and a half feet in the Kattegat.<sup>1</sup> On the shores of the northwest of Jütland this difference amounts to two feet, and on the western shore of Schleswig and Holstein it reaches nine feet. But the action of winds and storms is much more powerful than that of the tide. Thus the westerly winds, by driving back the waters of the North Sea into the Kattegat, produce differences of level that amount in the Sound to four feet. On the island of Foehr (western coast of Schleswig,) the same causes produce sometimes a depression of the water of four feet below their ordinary level, whilst at the same point there was in 1825 a rise of the sea (sturmflood) of twenty-five feet above the mean level, a total of twenty-nine feet difference of level at this point, owing to the action of the winds. Now, the northern extremity of Jütland is like a dyke, a spur, protecting, partially at least, the Kattegat against the violence of the waters of the North sea. But anciently Jütland was an archipelago, affording an easy passage to the sea and establishing a communication, now intercepted at these points, between the North sea and the Kattegat. It is quite possible, therefore, that there may have been formerly a greater unity of action between the movements of these seas, with their dependent domains.

**Sweden.**—It has been thought that at Malmoe, opposite Copenhagen, there had been a depression of the soil, because street pavements were found there one over another. But this repetition of pavements is easily explained by the vicissitudes of war. When, after a siege or a partial devastation, a city was rebuilt, they did not take the trouble to remove the rubbish; the ground was leveled and buildings were erected on the ruins of previous constructions. Thence a veritable superposition of layers in regular chronological order, as in the strata of which the crust of the globe is composed.

Mention has also been made of peat-bogs containing antiquities of the age of stone and covered over with embankments of marine formation, (*Jæravall*), in the south of Sweden. But it appears that the fact requires confirmation, just as that of the cottage buried under sixty feet of marine deposit, which was said to have been discovered when digging the canal of Sodertelje, near Stockholm.

**Geological Antiquity of Man.**—It has already often been supposed that proofs of this had been found in other countries, but they have always been unreliable. Thus the discovery made by Lund, in the caverns of Brazil, of human skulls having incisive teeth with edges parallel to instead of transverse to the axis of the mouth, which skulls

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<sup>1</sup> *Baggesen*. Already quoted.

were supposed to be associated with certain animal species now extinct, was based on a misunderstanding.<sup>1</sup> This was the result arrived at from the investigations of Dr. Reinhard, whom the Royal Museum of Copenhagen sent to the spot to complete the observations of Lund on the living and fossil fauna of Brazil. It would seem, moreover, that the account of this singular fact came from a third party, who must have erroneously stated what Lund himself had doubtless not properly explained.

The discovery made in the State of Missouri by Koch, who dug out the *Hydrarchos* and the Zenglodon, and the remains of a Mastodon, which was said to have been killed by man, might well be explained by the customs of the modern Indians, who often make use of any kind of bones, as well as of stones, to build their fire-places and other constructions of that nature.<sup>2</sup>

Allusions have been made to antique burial places found under an intact covering of lava at Marino, near Albano, in the States of the Church, although there are now in those countries only extinct volcanoes. But it appears that these tombs had been excavated in galleries by entering laterally under the ancient coating of lava. Such is, at least, the opinion of Professor Ponzi at Rome, a geologist of great merit, and of Mr. Pietro Rosa, an archæologist in great estimation with the Germans.<sup>3</sup>

The caverns containing bones in France and Belgium have given rise to long discussions, on account of the mixture they seem to present, of ancient human remains and supposed fossil bones. The fact that they have, from all time, and especially in the age of stone, been used as dwellings and places of security by man, complicates very much the question, which has not yet been decided in a definite manner.

The bone caverns of the South of France, among others that of Mialet, (*Basses-cevennes*), have been carefully explored by Mr. Emilien Dumas, who has arrived at the following conclusions: First, that man, the bear, (*Ursus spelæus*, Blum,) and the hyena (*hyæna spelæa*, Goldf.,) have certainly not inhabited these caverns at the same time; second, that the most ancient remains of industry which are found in them are of flint, cut into the shape of little hatchets, and very coarse pottery altogether similar to that of the lacustrine habitations of the age of stone in Switzerland.

Finally, much has been said about human bones, found under the product of an eruption of the Mountain of Denise, an extinct volcano of the Puy en Velay, in France. The discussion bore especially on the determination of the bones, which were at last recognized as really appertaining to man. But it appears that their burial at this point was posterior to the epoch of the activity of the volcano, and that it is explained by a land-slip. Moreover, the volcanoes of Auvergne and the Vivarais must have been still in operation at a quite recent geological epoch; for, in the diluvium of the valley of the Rhone, M.

<sup>1</sup> Memoirs of the Society of Antiquaries of the North, 1845, 1847, p. 49. *D'Archiac*, History of the Progress of Geology, II, 382.

<sup>2</sup> The author has had the opportunity of questioning Mr. Koch in person.

<sup>3</sup> Communicated by Mr. Gauden, at Lausanne.



Emilien Dumas finds only peridotous basalt proceeding from the ancient veins, and no felspathic basalt, peculiar to volcanoes with craters and tap-holes.

As a proof of the prodigious antiquity of man, the following fact, observed by Mr. Nilsson, is also sometimes stated. This savant has deposited in the museum of Jund a lance-head of silex of the age of stone, which had been re-touched since it was first cut in ancient times; this, however, is not an uncommon case. But, what had never been previously remarked, was, that before having been re-cut, and after having been first made, it had grown white on the surface, as has happened frequently to ancient specimens. Now, it was believed that silex required a very long time to thus whiten, and it was concluded that this lance-head must already have been very ancient when it was found and re-cut in the age of stone. But Mr. Steenstrup has observed numerous cases of silex very much whitened in a few years, as it were, under his own eyes, and by natural means. This depends merely on local and peculiar circumstances of position. The lance-head in question therefore proves nothing.

## V. COMPARISON OF THE NORTH WITH SWITZERLAND.<sup>1</sup>

We do not here entertain any idea of writing a treatise on the Archæology of Switzerland; our intention is merely to bring out the rather remarkable features of resemblance and correspondence that Switzerland presents with the North.

In Switzerland, the three ages of stone, of bronze, and of iron, are quite as well represented as in Scandinavia, but the most important discoveries in this order of things are of tolerably recent date.

**Lacustrine Habitations.**—It is some years since there were found in the lakes of Switzerland,<sup>2</sup> at certain points where the water is only from five to fifteen feet deep, piles corroded and worn, sometimes not above the level of the bottom, and therefore very ancient. In these localities the bottom of the water is strewn and sown with various antiquities, sometimes almost like the glass cases of a museum, in disorder. When the whole matter is examined with some degree of attention, we easily recognize that we are in the presence of the remains of ancient lacustrine dwellings, of constructions, of towns or villages, built upon piles, and then destroyed and forgotten for ages. There are lacustrine habitations of the pure age of stone, wherein, among hundreds of articles of stone, of horn,

<sup>1</sup> At the museum of Copenhagen there are in the corresponding divisions special series of Swiss antiquities of the age of stone, of the age of bronze, and of the first age of iron, well fitted for a comparative study. In Switzerland, the collections of Mr. Troyon and of the author present material for establishing the same comparisons. One may also obtain an idea of the subject by studying the two following works: *G. de Bonstetten*, Collection of Swiss Antiquities, Berne, 1855, folio; and *Worsaae*, *Afbildninger fra det Kongelige Museum for Norske Oldsager*; Kjoebenhavn, 1854.

<sup>2</sup> The discovery by Dr. F. Keller of the lacustrine habitations in Switzerland (at Meilen) dates from January, 1854.

of bone, or of wood, there has not been found the smallest vestige of any metal whatsoever, either of iron or even of bronze. Such is, for instance, the piled locality in the littoral bog of the very small lake of Moosseedorf, near Hofwyl, at two leagues from Berne, which has been examined with great talent by Dr. Uhlmann, at Münchenbuchsee.<sup>1</sup> Such is also the very extensive piling at Waugen in Lake Constance, near Stein, discovered and examined by a very intelligent peasant of the place, who had been specially taught and directed by Dr. Ferdinand Keller, the leader of the Society of Antiquaries of Zurich. It was also Dr. Keller who published the first general essay on the lacustrine habitations of ancient Helvetia, describing the piling at Meilen in the Lake of Zurich, and who has thus opened the path in this direction.<sup>2</sup>

The locality of Meilen presents the same assemblage of objects, the same character as Moosseedorf and Waugen, and belongs therefore also to the age of stone. But the presence of two specimens in bronze, a paltry little bronze bracelet of great simplicity and a bronze hatchet-knife of the lightest kind, proves that here the lacustrine establishment of the primitive population lasted until the commencement of the introduction of bronze into Switzerland. Meilen has also furnished a very small number of stone hatchets with holes in them for handles, articles which are entirely deficient at Moosseedorf, where stone hatchets without holes are abundant, as also at Meilen.

Elsewhere we have pile-works of the age of bronze in full development. One of the most remarkable places belonging to this category is situated in the Lake of Bienne, between Bienne and Nidau. It is called the *Steinberg* by the fishermen, who have long known it, as they have generally all these ancient pile-works, because they cannot cast their nets in them, on account of their liability to be torn. The *Steinberg* has been examined by the most active of the collectors in Switzerland, Colonel Schwab, at Bienne. Another remarkable place is the pile-work of the age of bronze at Morges, examined by M. Forel. We may form some idea of the richness of these localities, when we are told, that the *Steinberg* alone has contributed 500 bronze hair-pins, and that at Morges have been fished up forty bronze hatchets, without counting many other objects of the same metal.

Lastly a very recent discovery of M. Schwab's leads to the presumption that there have been in Lake Neufchatel lacustrine habitations of the age of iron. The indefatigable collector has found there, together with the gallic sword of iron, hatchets of iron, shaped like those of bronze, and which are evidently remains of the age of bronze, characterizing the beginning of the age of iron.

The existence of lacustrine constructions in Europe, after the introduction of iron, is confirmed by the following narrative of Herodotus: "The Pæonians of Lake Prasias (probably now Lake Takinos, in the

<sup>1</sup> *A. Jahn and J. Uhlmann.* Die Pfahlbalthümer von Moosseedorf. Berne, 1857.

<sup>2</sup> *F. Keller.* Die Keltischen Pfahlbauten an den Schwizerseen. Memoirs of the Society of Antiquaries of Zurich; 1854.

*F. Keller.* Pfahlbauten, Zweiter Bericht. Memoirs of the Society of Antiquaries of Zurich; 1858.

See also the eighth article of Mr. Troyon in the Guide to Swiss History and Antiquity Zurich, June 1858.

province of Roumelia, Turkey in Europe) could not be entirely conquered, (by Megabyzes, towards 520 before Christ.) Their houses are thus constructed: On very high stakes, driven into the lake are placed planks joined together; making a platform to which a very narrow bridge is the only causeway. \* \* \* \* On one of these platforms a hut is erected with a trap door well fitted which leads down into the lake." (Herod. V., 16.)

Remains of ancient lacustrine habitations have been discovered in the Lake of Annecy, in Savoy. In Ireland the name of *crannoges* is given to constructions that assume the form of more or less artificial islands, that served as places of refuge in times of political troubles until the seventeenth century.<sup>1</sup> Similar ancient artificial islands have also been observed in Switzerland. There is one in the center of the very small Lake of Inkwyl, between Herzogenbuchsee and Soleure.<sup>2</sup> There is likewise one in the center of the small Lake of Nussbaumen, a league to the south of Stein, in Thurgovia. Remains of lacustrine habitations must have been found in Brandebourg and in the peat-bogs of Hanover, and even their existence in Canada is spoken of. They seem to be indicated in Denmark by the abundance of antiquities in the bog-formations, many of which have commenced by being shallow lakes. In a peat-bog (especially at Vaugede, Brogaard, three leagues from Copenhagen) Mr. Steenstrup observed not only various antique instruments, but also fragments of pottery, coals, and broken bones bearing the marks of knives. He had thence come to the conclusion that man must have lived there in a stationary condition. As the locality was originally a lake of no great depth, it is all but evident that there was formerly a lacustrine habitation there.

Lastly, Messrs. Herbst and Steenstrup have just been making observations tending to the presumption that there were during the age of stone, habitations on piles in the marine bay of Noer, near Korsøer, in Seeland. This need not astonish us, as Dumont d'Urville describes and delineates villages built on piles in the sea at the harbor of Dorei, in New Guinea.<sup>3</sup>

When man stationed himself thus on piles, all the refuse of his industry and the fragments of his food were naturally thrown into the lake, where they were particularly well preserved, especially when they became gradually buried up in the peat and mud. These localities represent therefore for Switzerland the *Kjoekkenmoedding* of the north, and, in certain respects, surpass them, since the preservation of the substances is more thorough, and because they frequently contained, not only simple refuse, but likewise a number of excellent specimens. When such an establishment was surprised and burnt by the enemy, a thing that must have happened occasionally, what a quantity and variety of objects must there not have been swallowed up by the waters for the benefit of archæology!

<sup>1</sup> *Wilde*. Proceedings of the Royal Irish Academy. April, 1836; p. 220.

<sup>2</sup> The lake and its island are quite visible from the railway which passes near by.

<sup>3</sup> *Dumont d'Urville*. History IV., p. 607.

**Reason for the lacustrine habitations.**—The question is often propounded, what motive sufficiently powerful could impel the ancient people of Switzerland thus to station themselves on the water at great expense of trouble and labor.

Without pretending to decide this most embarrassing question, it will perhaps not be uninteresting to allude to the following circumstances.

The Romans must have introduced north of the Alps the art of masonry with stone and mortar, and that of burning bricks and tiles, for we find nothing like it in Switzerland connected with previous times. Before the invasion of the Roman element (fifty-eight before Christ) there would therefore have been no constructions except of earth and wood, such as in fact Cæsar found among the Gauls, whose civilization was the same as that of the Helvetians. But such constructions are always liable to be overthrown or fired. Now, a lacustrine habitation, as soon as the narrow bridge which connected it with the main land was intercepted, was no longer accessible except by boats, whose approach it was easy to prevent by means of stockades or rows of piles level with the water. This must have transformed these establishments into citadels almost impregnable, and much more safe than any construction of the times on the main land. When the water froze in winter, a space of broken ice could easily be kept open all round. This would prevent the crossing of wild animals, most dangerous during the winter season, whilst among savage tribes, as well as among civilized nations, hostilities are carried on by preference, during summer.

We can conceive, therefore, how great was the importance with which these lacustrine habitations must have been invested in high antiquity.

Reversing the question, we shall be led to see in the abundance in Switzerland of lacustrine habitations of the age of stone and of the age of bronze an indication that during those times the population of the country was divided into a multitude of independent tribes, often at war among themselves. With the age of iron a social organization of a much superior character and a certain centralization<sup>1</sup> seem to have caused in Helvetia the cessation of the petty internal wars and the substitution of great enterprises against a common enemy.<sup>2</sup> Thenceforward the lacustrine habitations lost a great deal of their importance; and thus we see them becoming very scarce at this epoch. If analogous establishments were maintained to a later time in Ireland, it is because intestine wars afflicted the country longer, and perhaps more generally than in any other part of Europe.

**Age of Stone.**—Let us see what the localities of the lacustrine habitations of this age, in Switzerland, have produced.

The pile-work of Moosseedorf has furnished an abundance of broken bones of animals. We find that here, as in the north, man has split

<sup>1</sup> A Roman inscription, preserved in the Maison de Ville of Lausanne, speaks of an Helvetic parliament, (*conventus helveticorum*.)

<sup>2</sup> Witness the remarkable expedition of the Helvetians, which met with such a sad overthrow at the battle of Bibracte before the irresistible genius of Cæsar, in the year fifty-eight before the Christian era.

open all the hollow bones to extract the marrow from them. Only the hollow bones of ruminating animals, whose interior is separated in two by a longitudinal partition do not present themselves here split in the direction of their length, and in that of this partition, as is the case in the *Kjoekkenmoedding* of Denmark. They are split irregularly and in every way. Many specimens bear the mark of the instrument with which the game has been cut up when it was eaten; but we perceive that these instruments were not provided with as good a cutting-edge as the knives and wedges of the primitive inhabitants of Denmark. The fact is that in Switzerland the fine flint of the north is not to be had, it was replaced by serpentine and dioritic stone. Notwithstanding this, the points of the piles of Moosseedorf, which show every stroke of the hatchet, as if had but just been made, bear witness to the skill with which the stone instrument was handled, and to the effect that might be produced by means of it. We might sometimes almost believe that the strokes had been made by steel hatchets, if we did not know otherwise.

The aggregate of the instruments and utensils of Moosseedorf<sup>1</sup> correspond generally with what is found in the North. We see especially the same stone hatchets, large and small, and again the same splinters of flint. Only Switzerland, being very poor in flint adapted to be worked up, the ancient splinters that one meets there, as well at Moosseedorf as elsewhere, have frequently been brought from other parts far distant, among others, to all appearance, from the south of France. This circumstance tends to establish the fact, that there already existed, in the age of stone, commercial relations between the different parts of Europe. At Meilen, at the Steinberg of Bienne, and at Moosseedorf, there have even been found some hacking knives and wedges of a kind of nephrite, which appears to be foreign to Europe, and which might very possibly have come from the East. The same case occurs in other countries. Thus a tumulus in Normandy has also furnished a hatchet of oriental nephrite.<sup>2</sup>

At Moosseedorf and at Wauwyl the layer of peat which incloses the remains of the industry of the lacustrine habitations of the age of stone, overlies immediately a whitish, marly, calcareous, tufous deposit, containing an abundance of palustrine shells, but without signs of man, unless it be the pointing of the piles, which have often been driven into this inferior deposit.

At Moosseedorf we find besides an abundance of chisels, awls, and divers pointed tools of bone, next stag horns carved, very coarse pottery, charcoal, and finally shapeless pebbles, but which are broken in such a manner as to present edges and angles, evidently indicating projectiles, like those of the North.

The same assemblage of objects is reproduced at Waugen, on Lake Constance.<sup>3</sup>

<sup>1</sup> The museum of Berne possesses a fine collection of them. Dr. Uhlmann, at Münchenbuchsee, near Berne, has also a handsome collection of them.

<sup>2</sup> *Montfaucon*, *Antiq. Expl. T. V.*, vol. II, p. 194. Quoted by F. Keller. Nephrite must have been in great request, because it combines great hardness with a greater toughness than that of silex, which shivers so easily.

<sup>3</sup> Collection of articles from Waugen, in the museum of Zurich, where there also found series from Meilen.

The lance heads of silex, so common in the North, are not found at Moosseedorf and at Waugen. On the other hand we find there arrow heads of flint, and sometimes even of rock crystal, only they are in general less delicately fashioned than in the North, where the art of working the silex was pushed to the highest degree of perfection, doubtless because the raw material was found there in all its beauty.

At Moosseedorf little stone wedges, fitted longitudinally into deer-horn handles, pointed at the other end, constitute excellent knives, with transverse edges, after the Greenland pattern. Stronger wedges inserted in one end of a large deer antler, the other end of which had been cut into a mortice, to receive in its turn a transverse wooden handle, represented hatchets properly so called. At Waugen these wedges have also been found, fitted simply into handles, made of pieces of roots or crooked branches. A similar specimen, in perfect preservation, was found latterly near Halle, in Prussia, and can be seen in the museum of that town.<sup>1</sup>



Fig. 16. (†) Switzerland.



Fig. 17 (†) Switzerland.

Splinters of silex from Waugen and from Moosseedorf, fitted laterally into wooden handles, in the cleft of which they were fixed by means of pitch still in preservation, evidently represent saws. They are, if not neatly toothed, at least tolerably crenelated, so as to be capable of sawing as they are incapable of cutting or cleaving. Moreover there is nothing else in Switzerland that could have been used as a saw, whilst bones, deer horn, and even stone, are frequently found with the mark of this instrument. In the North the saw is often represented by pieces of flint in the shape of a crescent, of fine workmanship, sometimes with well-defined teeth; but this kind is wanting altogether in Switzerland. Here, on the other hand, the splinters of flint are frequently crenelated, whilst in the museums of the North they are sometimes seen with a natural edge quite sharp and fresh, as if they had not yet been used.

At Waugen and at Moosseedorf have been found hatchets and wedges of stone, especially of serpentine, bearing the mark of a saw. As the rock did not split with a blow, as silex does, they were obliged to resort to the much more laborious alternative of the saw to shape their implements. Pieces commenced and others half finished display clearly the manner of procedure. Having chosen a rounded pebble of the desired rock, they began by sawing into it grooves of some millimetres (about four hundredths of an inch) in depth, which determ-

<sup>1</sup> Communicated by Mr. Silvius Chevannes.

ined so many tolerably regular planes of cleavage. They continued frequently the process of smoothing by means of a piece of quartz, and they gave the last finish with grindstones of different degrees of fineness.

Marks of the process by the aid of the saw do not yet appear to have been observed in the North, where the raw material, the flint, was roughed down and fashioned so well, simply by cleaving, that nothing was left to the grindstone but to give a finish to certain pieces.

The huts or cabins of the lacustrine establishments appear to have been of a round shape, and constructed of lattice or wicker-work daubed with clay in the interior; for there have been found fragments of various sizes of this interior coating calcined, doubtless by conflagration, and very well preserved, so that they display the interlacing of the twigs. The same mode of construction was still in use among the Gauls in the time of Cæsar; it is seen represented among the bus-reliefs of the column of Antoninus.

At Waugen, pieces of cord and shreds of tissues, made from a vegetable substance difficult to determine accurately, but resembling hemp and flax, settle the question of the ancient cultivation of a textile plant. The tissue being plaited and not woven in a weaver's loom, it seems that this latter was not yet invented. A most unexpected circumstance, but perfectly authenticated, is the presence of carbonized grain at Moosseedorf, and that as far down as the bottom of the peat layer containing ancient objects, exclusively belonging to the age of stone. At Waugen the same discovery was made of carbonized grain, and in great quantity, at a place which appears to have been the locality of an ancient storehouse which was burned. Professor Oswald Heer, at Zurich, the author of one of the finest works on fossil flora, has examined this grain from Waugen, and has pronounced it to be the ordinary wheat, (*Triticum vulgare*,) the starch wheat, or "grande epeautre," (*Triticum dicoccum*,) and double-headed barley, (*Hordium distichon*.) Therefore the population of the age of stone, occupying the lacustrine habitations of Switzerland, raised crops of grain.<sup>1</sup>

This fact might lead us to admit of a second age of stone, subsequent to that of the *Kjoekkenmoedding*, if it were proved that the people who accumulated these heaps of shells on the coast of Denmark were not acquainted with agriculture.<sup>2</sup>

**Age of Bronze.**—As to what concerns this age, the objects of metal which characterize it in the north, present the greatest analogy with

<sup>1</sup> There have also been found at Waugen quarters of apples and of the wild pear, (*Pyrus malus* and *Pyrus communis*.) They have been carbonized by fire, which had thus insured their perfect preservation. At Moosseedorf Mr. Uhlmann found the water-caltrop, (*Trapa natans*, L.) which has now almost disappeared in Switzerland. As to the presence at Waugen of beech nuts, (*Fagus silvatica*,) of pine cones, (*Pinus silvestris*,) and the seeds of the raspberry and blackberry, (*Rubus idæus* and *Robus fruticosus*,) there is nothing surprising in it. But the most abundant fruit of the lacustrine habitations of the age of stone in Switzerland is the filbert, (*Corylus avellana*.)

<sup>2</sup> Mr. Heer has just discovered the carbonized fruit of flax (*Linum usitatissimum*) in the lacustrine establishments of the age of stone, at Waugen and at Robenhausen, (lake of Pfäffikon,) and well characterized fragments of extremely coarse carbonized bread, found by Mr. Messikommer, at Robenhausen.

those of Switzerland. We see the same hatchets and hatchet-knives, the same swords, the same bracelets, and with the same ornaments, save some slight local variations such as one observes everywhere. We recognize evidently a tolerably uniform civilization during this age throughout central Europe; and this is conceivable, inasmuch as a regular trade must necessarily have furnished Europe with tin, which is found only in so few places, and which, with about ten times its weight of copper, constituted the ancient bronze, as we have stated in our "*Considérations Générales.*"

**First Age of Iron.**—The ante-Roman age of iron, that is, previous to the introduction of civilization into the country; and which we, after the antiquaries of the North, shall call the *first age of iron*; was recognized in Switzerland only a few years ago.<sup>1</sup>

The most important discovery belonging to this epoch was made at the Tiefenau, near Berne.<sup>2</sup> A wide excavation in what has evidently been a battle field brought to light an abundance of objects of iron, such as the iron work of chariots, including the tires of wheels; next, various arms, among the rest nearly a hundred Gallic swords, long, straight, double-edged, with a rounded extremity, and without guard or croisûre; and again, fragments of iron coats-of-mail, bridle bits, and harness gear, but no horseshoes, although there was no lack of the bones of these animals. There were, besides, objects of bronze, such as clasps for mantles or fibulæ, articles of glass, pottery of a rather coarse kind, but turned in the lathe, a little hand mill, and finally about thirty coins, which gave a peculiar value to the whole of the discovery. These coins are of bronze, cast, then stamped at Marseilles, of the best time of Greek art, (a head of Apollo, left side, crowned with laurel; on the reverse the superb tossing bull, under which we read in full letters *ΜΑΣΣΑΙΗΤΩΝ*;) then silver coins, stamped, græco-massilian, (oboli,) stamped silver coins, Gallic barbarian, with Macedonian and Marseillèse prototype, and lastly, cast barbarian, pinch-beck coins, among which there are some that look as if they might be Helvetian. The presence of these coins, combined with the absence of all articles of Roman style, leaves no doubt as to the ante-Roman age of the articles discovered.<sup>3</sup>

The Tiefenau is not the only spot that has furnished objects of this epoch, which are far from being rare in Switzerland. Thus several tumuli, belonging to it, having been carefully searched by Messrs. Keller and Troyon, have revealed the custom of human sacrifices among the ancient Helvetians, who participated, therefore, in the sanguinary rites of the Gauls.

It behooves us to remark here, that in addition to the foreign Marseillèse and Gallic coins, they find also indigenous pieces of this epoch.

<sup>1</sup> The supposition that the *Kjoekkenmoedding* are anterior to the lacustrine habitations of the age of stone in Switzerland is also borne out by the presence in these latter of domestic animals, which are wanting in the *Kjoekkenmoedding*.

<sup>2</sup> Collection of articles in the museum of Berne.

<sup>3</sup> See the excellent article from *Mr. Jahn*, in the Memoirs of the Historical Society of the Canton of Berne, II, 350, and in the *Jahrbuch des Vereines von Alterthumsfreunden un Rheinland*, XXI, 135.



They are of the same kind as the Gallic barbarian coins, but they bear the names of Helvetic chiefs, among whom is found that of Orgetorix, so well known through Cæsar's narrative. The inscriptions on these coins, as well as certain rare lapidary inscriptions, are in Greek or Etruscan characters.<sup>1</sup> It is known, moreover, that Cæsar found the Greek alphabet in use among the Helvetians.

It is also but few years since the learned Danish archæologists, Messrs. Herbst and Worsaae, arrived on their part, and independently, at the recognition of this first age of iron in the North.<sup>2</sup> The correspondence that exists between the antiquities of this epoch in Denmark and in Switzerland is truly remarkable; only they have not yet found in the former any Greek medals. This is natural enough, for being already tolerably scarce in Switzerland they would be still more so further North, where they may nevertheless yet be found some day. The only medals that have presented themselves hitherto in company with objects of this epoch are some pieces of Roman money of the first and second century of our era. As to the rest, we meet in the North with the same iron sword, without guard or croisûre, the same iron hatchet, shaped like the bronze hatchet, the same bridle bit, and even the same coat-of-mail, as in Switzerland.

A remarkable circumstance is, that the iron arms of this epoch show in the North a forge workmanship of rare perfection, and which has probably never since been surpassed. Thus we meet with swords of beautifully damasked steel.<sup>3</sup> There are even some articles, such as lance-heads, that are ornamented with chevron tracings, sometimes inlaid with silver, the whole in the style of the corresponding articles of the age of bronze, which denotes clearly the commencement of the age of iron. In Switzerland there is also superior workmanship, observed in certain specimens of this epoch. Thus one of the fragments of a coat-of-mail from the Tiefenau is formed of rings which are only five millimetres (0.2 inch) diameter, and which are forged with the greatest regularity, and the iron swords that M. Schwal found in Lake Neufchatel with iron hatchets shaped like the bronze hatchets, have iron scabbards admirably ornamented, in one case even with silver inlaying.<sup>4</sup> In other respects we see the same kind of mountings and scabbards as those of Tiefenau, where there has not, however, been found the iron hatchet of the same form as the one of bronze.

Lastly, there is found—from the south of Italy, all through Switzerland and Germany, as far as the North—certain bronze vases, ornamented with figures of animals, of superior execution, and more rarely

<sup>1</sup> *Mommsen*. Nordtrueskische Alphabete. Memoirs of the Society of Antiquaries of Zurich, VII, 1853.

<sup>2</sup> *Worsaae*. Afbildninger fra det Kongelige Museum for Nordiske Oldsager; Kjoebenhavn, 1854.

<sup>3</sup> Communicated to the author by Mr. Strunte, one of the learned and amiable conservators of the Museum of Antiquities at Copenhagen.

Greek coins of Cyzicus, Egina, and Athens, many of which are of the most ancient stamping and found in the Grand Duchy of Posen in Prussia, strongly bear out what is advanced concerning the ancient commercial relations of the North with the South and the East. See *Levezow*, Memoirs of the Academy of Berlin, 1833, p. 204.

<sup>4</sup> See the second memoir of Mr. Keller, already quoted, on the lacustrine habitations. Memoirs of the Society of Antiquaries of Zurich, vol. XII, sheet 3, plate III.

with human figures, less perfect; the whole in a style to a certain degree Etruscan or Archaic, and representing a state of art, a civilization which evidently preceded the Roman development. We do not mean thereby, that this civilization was anterior to the first times of Rome, which probably are connected with it; but merely, that in the country where it shows itself, it is anterior to the invasion of the Roman element, so called. It must have immediately preceded the latter and been superseded by it, so that we must occasionally find it in immediate contact with the Roman element itself.

The most curious specimen of this Etruscan type found in Switzerland is the bronze of Græchwyl, preserved in the museum of Berne,



Fig. 18. (¶)

Bronze from Græchwyl. Switzerland.

and described by M. Jahn.<sup>1</sup> It is an ornament that was riveted to a bronze vase, of which there remained some fragments. It presents features of resemblance with the Assyrian style, for the drawing of the muscles in the legs of the lions, and that of the manes is in the manner of that of the bulls of Nineveh.

As an example of the specimens of Germany, we may allude to the bronze vase of Mayence, preserved in the museum of Copenhagen, and ornamented with a handle (chasse) carved around its circumference; also another vase of the same kind found in Hanover and very well described by Mr. Einfeld.<sup>2</sup>

<sup>1</sup> *A. Jahn. Etruskische Alterthümer gefunder in der Schweiz; Memoirs of the Society of Antiquaries of Zurich, vol. VIII, sheet 5; Zurich, 1852. See also Gerhard, Archäologische Zeitung; Berlin, 1854, p. 177.*

<sup>2</sup> Independent pamphlet without any date.

Denmark itself has furnished its contingent of specimens of this type, for example the bronze vase of Himlingøie in Seeland, preserved

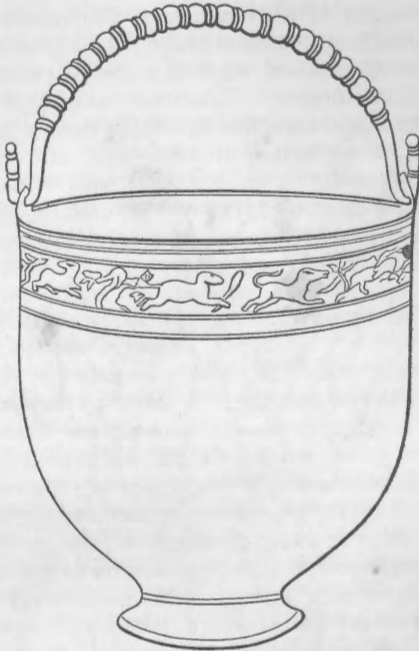


Fig. 19. (†)  
Bronze Vase from Himlingøie. Denmark.

in the museum of Copenhagen. We may also here speak of the bronze helmet-crest, found in the peat-bog of Viemose, near Allesoe, in the



Fig. 20. (†)  
Bronze crest, Denmark.

island of Fyen, with a great quantity of various objects of the first age of iron, but also with some Roman coins of the two first centuries of our era.

Finally, the museum of antiquities of the south, at Copenhagen, contains bronze vases brought from Italy, which combine the characters of the specimens of Græchwyl with those of the vases of Mayence, of Hanover, and of Himlingøie. We find on them the same animals well executed; human figures less skillfully drawn though expressive, the Greek helmet, the Etruscan palm-leaf, and the corresponding ornaments.

It seems, therefore, that the first age of iron in Switzerland and in the North is connected with the epoch of civilization in Greece which preceded the times of Roman splendor.

**Human races.**—The great subject of ancient human races is not yet much advanced in Switzerland. Scarcely anybody but M. Troyon has gathered materials for its solution. On examining his collection, which contained specimens from the first age of iron inclusive to the fifteenth century of our era, M. Retzius has grouped the skulls into several series, each of which represents a separate people. Thus there were found among them Etruscans, Celts, Goths, Slaves, and Huns. The Goths, with whom are included the Burgundians, are about equal in number to the Celts and Romans. The Celts are more numerous than the Romans. The Etruscans, the Slaves, and the Huns are merely exceptional. These races are precisely those which Mr. Troyon had already discovered to have formerly inhabited the country, merely by examining the remains of their industry, and without any reference to their skulls.<sup>1</sup>

Since the visit of Mr. Retzius in 1857, the collection of M. Troyon has been augmented by some skulls of the age of bronze, found in the neighborhood of Aigle and Sion. They represent the rounded type of the age of stone. But, on the other hand, the discovery in the same localities of numerous cubical tombs<sup>2</sup> so characteristic of the age of stone, and containing, nevertheless, an abundance of bronze, had brought Mr. Troyon to the conclusion that at these points of the valley of the Rhone the primitive race of stone had continued to subsist during the age of bronze, whose civilization it adopted, saving what concerned the religious usages of burial.<sup>3</sup>

With the introduction of iron into Switzerland seems to correspond the arrival of this same race, which must have brought the civilization of the age of iron into the North. This is more or less indicated by the remarkable analogy of style above alluded to between the objects of the ante-Roman epoch of iron in Switzerland and those of the North. Moreover, a well preserved human skull, taken from a grave of the Tiefenau and plainly characterized by the articles found with it as

<sup>1</sup> Communicated by Mr. Troyon.

<sup>2</sup> Tombs of unwrought flag-stones, with an interior hollow two or three feet in length, and about the same in width and height, and in which the body has been placed in a bent position, say sitting.

<sup>3</sup> Troyon. Statistics of the Antiquities of Western Switzerland, fourth article. Guide to the History and Antiquities of Switzerland, Zurich, March, 1856.

having belonged to this first age of iron, presents exactly the same profile as the skull of Sanderumgaard, Fig. 8. The height of the Swiss skull is identically the same, and its length is also a little—about five millimetres (0.2 inch)—greater than that of the Danish skull. This skull from the Tiefenau is in the museum of Berne, with another one of the same age, less perfect; but presenting the same elongation fore and aft.

If the cases of survival of the primitive human race are rare exceptions, it is because the introduction of the civilization of the age of bronze appears to have been effected less by purely pacific intercourse than by means of a great social derangement, such as we have before alluded to when speaking of the first appearance of domestic animals.<sup>1</sup>

We have, therefore, in the discovery of Aigle and Sion, one of these clearly defined cases of an ancient population continuing to exist in the mountains whilst it was disappearing in the open country, where it was supplanted by new-comers.

It may very well be, that in Europe the succession of the three ages of stone, of bronze, and of iron, corresponds to the succession of three distinct human races, which successively supplanted each other without mixing or coalescing, something like what is taking place at the present day in North America, where the white race is driving out the red. For, if the distance that separates these two races is greater than the distances that we may suppose to have existed between the races that followed each other in Europe, this circumstance would be likely to have been greatly compensated by the greater ferocity of manners in ancient times, causing antagonisms of race sufficient to explain the extermination of the ancient people by the invaders. Lastly, the question is complicated by this other one not yet scientifically solved, namely: that of the unity of the human species. For, according to the observations of learned men of great merit, the perfectly distinct types of the human races, such as the white, the red, and the black, do not produce by their crosses an intermediary hybrid race, which can propagate and maintain itself in virtue of its own fecundity.

*Apropos* of what is going on in America at the present day, we will quote the following passage, borrowed from a recently published work:<sup>2</sup>

“Civilization as it approaches them, takes no hold of these hordes, (the red men of the United States,) it drives them back, and crushes out the small remnant of life which is still in them. There is near Vancouver a territory where there formerly flourished a powerful tribe. The plow came one day and dug its furrow in that soil hitherto untouched by the labor of man; immediately fevers spread through the district, and nearly the whole Indian population was swept off. Such is the fate that civilization has in store for the red-

<sup>1</sup> Mr. N. G. Bruzelius has observed in Scania a similar case of a burial place of the age of bronze with a skull of the type of the age of stone. *Annaler for nordisk Oldkyndighed og Historie. Kjoebenhavn.*

<sup>2</sup> *Paul Kane. Wanderings of an Artist among the Indians of North America: London, 1859. Revue des deux Mondes, of the 15th August, 1859. One perceives that it is an artist who is painting; his coloring is vivid, but it does not follow that his outlines are false.*

skin. Thrust backwards by European invasion, brutalized by the spirituous liquors which the whites bring to him, the Indian will retire further and further north; he will fly until he finds himself stopped by the everlasting polar ice; there, after having cast his nets in vain and shot his last arrow, having no further hope but in the home promised by the Great Spirit, he will lie down on the snow, that will soon cover him with its winding sheet, and with him a whole race will disappear for ever from the face of the earth."

**Domestic Animal Races and Wild Species.**—The subject of animal species and races is more advanced in Switzerland than that of the human races. There have been a large number of bones collected, to the study of which the learned Professor Rutemeyer, of Basle, has specially devoted himself. The following is a summary of the results he has obtained up to this time.<sup>1</sup>

The pile-works of the age of stone of Wangen, (W.,) on Lake Constance, of Wanwyl, (W. W.,) in the canton of Lucerne,<sup>2</sup> and of Mosseedorf, (M.,) near Berne, have furnished, among domestic animals:

*The Dog.*—A very constant and uniform race in the various localities; it was rather small, its size being a medium between the hound and the pointer.

*The Goat.*  
*The Sheep.* } Small races. In all three localities.

*The Cow.*—A small race, with greatly curved horns. Everywhere.

The same localities have also furnished the following wild animals:

The Brown Bear, (*Ursus Arctus*, L.,) M.

The Badger, (*Meles vulgaris*, Desm.,) M. W. W.

The Martin, (*Mustela martes*, Briss.,) M. W. W.

The Polecat, (*Mustela putorius*, L.,) M. W. W.

The Ermine, (*Mustela herminea*, L.,) W. W.

The Otter, (*Lutra vulgaris*, Erxl.,) M.

The Wolf, (*Canis lupus*, L.,) W. W. W.

The Fox, (*Canis vulpes*, L.,) Everywhere.

The Wildcat, (*Felis catus*, L.,) M. W. W.

The Hedgehog, (*Erinaceus europæus*, L.,) M.

The Beaver, (*Castor fiber*, L.,) M. W. W.

The Squirrel, (*Sciurus europæus*, L.,) M. W. W.

The Wild Boar, (*Sus scrofa ferus*, L.,) M. W. W.

The hog of the peat-bogs, (*Sus scrofa palustris*, Rut.) A wild race very peculiar, established by Mr. Rutemeyer, who, however, does not yet lay it down as a separate race.<sup>3</sup> In all the three localities.

The Elk, (*Cervus alces*, L.,) Everywhere.

The Deer, (*Cervus elaphas*, L.,) Everywhere.

The Roe-buck, (*Cervus capreolus*, L.,) Everywhere.

<sup>1</sup> Memoirs of the Society of Antiquaries of Zurich, XIII, January, 1860.

<sup>2</sup> Examined with minute care by Colonel Suter at Zofingue.

<sup>3</sup> Mr. Rutemeyer is going to publish it in the Memoirs of the Helvetic Society of Natural Sciences.

- The Urus, (*Bos primigenius*, Baj.) M.  
 The Bison, (*Bos bison*,) W. W.  
 The Wild Ox, (*Bos taurus ferus*,) M.  
 The Gos-hawk, (*Falco palumbarius*, Gmel.) M. W. W.  
 The Sparrow-hawk, (*Falco nisus*, Gmel.) M.  
 The Ring-dove, (*Columba palumbus*, L.) M.  
 The Wild Duck, (*Anas boschas*, L.) M. W. W.  
 The Teal, (*Anas querquedula*, L.) M.  
 The Gray Heron, (*Ardea cinerea*, L.) M.  
 The Fresh Water Turtle, (*Cistudo europæa*, Dum.) M.  
 The Frog, (*Rana esculenta*, L.) M. W. W.  
 The Salmon, (*Salmo salar*, L.) M.  
 The Pike, (*Esox lucius*, L.) M. W. W.  
 The Carp, (*Cyprinus carpio*, L.) M.  
 The Dace, (*Cyprinus leuciscus*, L.) M.

It is well worthy of remark, that the hare (*Lepus timidus*) is wanting here entirely, as in the *Kjoekkenmoedding* of the north. This would seem to indicate that the primitive inhabitants of Switzerland, like those of Denmark, had the same superstitious ideas concerning the hare that the Laplanders of the present day have.<sup>1</sup>

Bones gnawed by dogs and bearing the impress of their teeth are numerous in Switzerland, as in the north. There are likewise bones, and especially deer horns, gnawed by rats and mice.

The domestic hog and the horse appear to be wanting in the age of stone in Switzerland. Some isolated and doubtful facts might lead us to believe in the presence of the horse during the age of stone in Switzerland, but there is no proof that this animal existed there at that time in the domestic state. The *Benedictiones*, previously quoted, speak of the wild horse, *Equus feralis*. But in the middle ages what were meant thereby were horses that were allowed to run wild, and for whom they had no stables. One additional fact is curious—horse flesh is mentioned as appearing on the table at St. Gall, whilst in the north the Church excommunicated those who ate it.<sup>2</sup>

M. Schwab having sent to Copenhagen some bones from the Steinberg, which are known to have belonged to the age of bronze, it became possible to compare them with the ancient bones of Denmark. This comparison, although made between a small number of specimens, has already furnished some very interesting results. There was found among these specimens from the Steinberg a jaw-bone of a dog, exactly corresponding with the dog of the bronze age of Denmark. There was also the domestic hog, and, moreover, the long bones of the sheep, even a little more slender than those of the sheep of the bronze age of Denmark. A very small tooth of a horse established still another connecting link with the north.<sup>3</sup>

<sup>1</sup> Cesar states that the *Britannia* ate neither the hare, the hen, nor the goose. *De bello gallico*, V. 12.

<sup>2</sup>The hog of the turf-bogs is still found, it seems, as a domestic race in the canton of the Grisons, (Switzerland.) This same canton also possesses some very small races of cows, goats, and sheep, the study of which, about to be undertaken by Mr. Rutimeyer, cannot fail to be very interesting.

<sup>3</sup>Mr. Troyon has found at Echalleus, in burgundian tombs of the fifth and sixth centuries of our era, horses of as great size as the largest we have now.

Considering these facts, it is quite likely that the analogies between the ancient domestic races of Switzerland and those of the north may be carried out still further.

The polar regions and high mountains are naturally enough places of refuge for the ancient races, who are driven into them by the pressure exercised by new comers, who spread themselves out into the more fertile and more easily accessible regions. This is so with man, as it is with many of the lower animal species. The reindeer, for instance, and the great penguin, are generally supposed to be indigenous to high latitudes, just as the wood grouse is reputed to belong to high mountainous districts. And yet, from all that can be observed, it is merely because they have held their ground there longer in spite of the encroachments of man, who has exterminated them in more accessible regions.

The reindeer gives occasion for a peculiar remark. Where this animal has passed, the cow refuses to browse, thereby establishing an antagonism, that leads sometimes to deadly conflict, between the agricultural settlers of the north of Sweden and the nomadic Laplanders, who breed the reindeer. We can easily conceive, therefore, that the fact of the introduction of a domestic bovine race may have caused the destruction of the reindeer in the temperate regions of Europe, where it has existed, not only in Denmark, as we have already seen, but also in France, Belgium,<sup>1</sup> England,<sup>2</sup> and Switzerland.<sup>3</sup> It is, however, well to remark that the remains of the reindeer found hitherto, might very well belong to the glacial epoch, and might consequently all be anterior to the advent of man in Europe.

We may therefore foresee what singular interest, in an antiquarian point of view, must attach to the polar and the alpine regions, and what important questions will yet find their solution in the last mentioned countries.

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## VI. CHRONOLOGICAL QUESTION.

**State of the Question.** The general chronology of the three great phases in the development of civilization in Europe, called the age of stone, the age of bronze, and the age of iron, is purely relative, like the chronology of the geological formations. It is not known when the age of stone or that of bronze, or even that of iron, commenced, nor how long a time each of them lasted. We merely know that what belongs to the age of bronze succeeded the order of things of the age of stone, and preceded that event, so important to the destinies of mankind, the introduction of the manufacture of iron. This is itself a great deal, for it is but a short time since nothing at all was known of what had

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<sup>1</sup> *Pictet*. Treatise on Palæontology. Geneva, 1853, vol. 1, p. 356.

<sup>2</sup> *Owen*. A History of British Fossil Mammals and Birds. London, 1846, p. 479.

<sup>3</sup> Bulletin de la Société Vaudoise des Sciences Naturelle. December, 1859.



occurred previous to the present age of iron. But we are so accustomed to precise dates in what has hitherto been understood as *history*, without troubling ourselves whether the figure indicated was true or purely imaginary, that we cannot become accustomed at once to the system of simply relative data of archæology; to a history without dates. Dates figure to advantage even in poetry. Witness the celebrated lines of Victor Hugo, on Napoleon II:

Eleven and eighteen hundred, fateful year—  
Which saw the nations, under gloomiest clouds  
And prostrate, wait till Heaven should give assent.

We have accustomed ourselves to relative dates in geology, where we have, and shall continue to have for a long while, nothing else. We have to make up our minds to it also in archæology, for history, with positive and direct dates, does not go very far back.

The most ancient authentic geological data do not go further back than the era of the Olympiads, (776 before Christ,) and the most ancient Greek inscriptions that are known do not reach any further. Previous dates are computed in genealogical series of generations, either of names of kings or names of priests, for the authenticity of which there is no warrant. Thus the historian Hectæus, of Miletus, who lived about five hundred years before Christ, fixed the epoch, when the gods still intermingled with men, at sixteen generations before himself, which would make about nine centuries before the Christian era. It is true that he met with opponents; some added a certain number of generations to his account, others, more rationalistic, permitted themselves to doubt that men had descended from the gods.<sup>1</sup> This may give an idea of the value of the Greek dates previous to the era of the Olympiads.

As to the stamped coins, which are considered the most ancient, they are the Greek silver pieces of Egina and Cyzicus, in Asia Minor, without any date or legend, but which are thought to be of the end of the eighth century before Christ.<sup>2</sup> Now, at this epoch iron must have been in use, and for some time previous, for the above coins must have been impressed by means of steel stamps, cut with steel gravers; and it is not by such a proceeding that people begin on first coming to the use of iron.

We may therefore calculate that iron was known in the South at least a thousand years before the Christian era; that is to say, about 3,000 years ago.

We often hear it said that the knowledge of the metals has spread very slowly from the South to the North, where it did not arrive till

<sup>1</sup> *Herodotus* II, 143.

<sup>2</sup> These pieces have an effigy only on one side. It is an animal, or only the head of an animal, without any inscription. On the other side we find the mark of the anvil on which the piece was placed to give it the stamp, the *quadratum incusum*. The most ancient stamped Roman coins are of 269 before Christ. They are of silver.

very late. But this is nothing but pure and simple conjecture, to which may be opposed the following considerations :

**Ancient Commercial Relations.** The presence of foreign mineral substances, flint, and nephrite, among the remains of the age of stone in Switzerland, would indicate commercial relations with distant parts even from the highest antiquity. This ought not to surprise us, when we see that the Indians of the United States, who belong, by their civilization, to the age of stone, are very fond of traveling, and carry the beautiful red pipe-stone of *Coteau des Prairies* to great distances from its bed.

The example of these Indians of the United States may perhaps be quoted in favor of the opinion, that the use of stone and metals might have existed simultaneously in the same country, so that the difference of these materials in Europe might arise, not from different ages, but from different degrees of civilization or of wealth at the same epoch among the same people. But the case in question rather proves the contrary, for the Indians have been in such haste to adopt iron, that they no longer make use of their ancient instruments of flint, except for the purpose of amulets, and they have even forgotten how to make them. These articles have thus passed, among them, into the class of antiquities.

During the age of bronze a regular commerce, as has been seen, must have necessarily existed between the different portions of Europe, where there prevailed a tolerably uniform civilization, at least in what appertains to the technical arts.<sup>1</sup>

How much more likely it is that similar commercial relations, and a similar uniformity and contemporaneousness in the most important elements of industry must have existed in Europe from the earliest times of the age of iron. As regards the North, in particular, it appears that at this epoch commercial relations were entertained not only with the South, but perhaps even with the East. For the bronze vases, above alluded to, display among others, such animated figures of lions, that they must, one would think, have come from the hands of artists who had these animals before their eyes. Other articles which the South, perhaps Phœnician industry, furnished to the North, are the *Millefiori*,<sup>2</sup> some specimens of which have been found in Denmark and Sweden. In return the North supplied ancient Greece with amber from the Baltic.

It is also known that the shores of the North Sea were visited in the fourth century before the Christian era by Greek navigators, who must have reached a latitude of 64° or 66°, for they allude to a duration of two or three hours as that of the shortest night. They may even perhaps have penetrated to the Arctic Circle, of which they had, at any rate, a direct or indirect knowledge, inasmuch as they knew that the

<sup>1</sup> The Museum of Copenhagen contains a series of Italian antiquities of the age of bronze, corresponding very well with what is found in the north.

<sup>2</sup> Glass balls, with an interior nucleus of colored glass mosaic work, perhaps enamel. They are found in the Etruscan and Egyptian burial places. *Minutoli*. Über die Anfertigung und Nutzenwendung der farbigen Gläser bei den Alten. Berlin, 1836.

day there was twenty-four hours long at the summer solstice.<sup>1</sup> Now, they could not have failed to mention so important a fact as the employment of bronze, instead of iron, for arms and cutting instruments, as they were enabled to describe, among other things, how grain was thrashed in covered barns, on account of the rainy climate.

Lastly, the *Sagas* and the most ancient traditions of the North all refer to the age of iron and know nothing of an age of bronze.<sup>2</sup>

**Ancient Civilization of the North.**—The North, especially Denmark, is rich in flint of a very fine quality, peculiarly adapted to be fashioned by the simple action of cleavage. This facilitated the work extremely and allowed instruments to be made of very considerable usefulness, for flint is harder even than steel.<sup>3</sup> This very material circumstance must have contributed, and perhaps very extensively, to bring about a superior development of the primitive civilization in this country. Thus some of the daggers of flint in one piece, and with ornamented handles, which are found in Denmark, are the finest articles of the kind that have been anywhere observed.

The civilization of the age of bronze would appear also to have reached its culminating point especially in the North, judging at least from the contents of the museums.

Finally, as to what regards the first age of iron, direct and indirect archæological data give us a glimpse of the fact, that the North had at this epoch a considerably advanced civilization, entirely independent of that of Rome. This was scarcely suspected generally, for the attention of the literary public had been so much absorbed by the Roman element, that this had concealed, as it were with a veil, a whole anterior growth which is just now beginning to show its outlines above the horizon.<sup>4</sup>

It would seem that the shores of the Baltic, with their Danish archipelago, the soil of which is so fertile, have furnished anciently a center of civilization, like the countries of the Mediterranean with their Greek archipelago.

All this certainly does not tend to show that the knowledge of the metals was late in arriving in the Scandinavian north. The aggregate

<sup>1</sup> *Lelevel*. Pytheas of Marseilles and the geography of his time. Brussels, 1836; German edition. *Hoffmann*. Pytheas und die Geographie seiner Zeit. Leipzig, 1838.

<sup>2</sup> *Munch*. Die Nordisch-germanischen Völker. Lubeck, 1853; p. 7.

<sup>3</sup> If siliceous were not so liable to break, and had the tenacity of steel, it would be of superior usefulness to the latter.

<sup>4</sup> At the present day the Scandinavian north can boast of an intellectual cultivation of which there is but a very vague idea in the south. Here are some significant facts: Prof. Ursin published, some twenty years ago, at Copenhagen, a popular astronomy, for the Icelandic translation of which he had, in Iceland, 600 subscribers, among whom figure simple farm servants of both sexes. In 1840 the reading of the Icelandic peasants consisted of a new and quite good translation, not of the Wandering Jew of Eugene Sue, but of Homer's *Odyssey*. Prof. Berlin, of Lund, published, in 1852, on the natural sciences, a popular treatise, of which 20,000 copies have been disposed of in Sweden, and 40,000 in Norway. As for Denmark, its capital passes for the Athens of the North, as well in what concerns the sciences as in what belongs to the scenic arts—music, painting, and especially sculpture. The excellence of the Scandinavian character has been well understood by a Bernese of the last generation. See the remarkable work of *Ch. F. de Bonstetten*: *The Southern Man and the Northern Man*. Second edition; Geneva, 1826.

of the facts lead us, on the contrary, to consider all the portions of Europe as having most probably passed, very nearly simultaneously through, first the age of stone, then the age of bronze, and lastly the first age of iron. This is natural enough, for in a part of the world at once so small and so interspersed with seas, and consequently so easy of access, the great industrial and social revolutions, prepared beforehand in the East, must have been introduced and spread rapidly.

**Absolute Chronology.**—If nothing is known respecting the absolute date of the age of stone and the age of bronze, it is at least evident from the large accumulation of their remains, that they have each lasted a very long while. In Denmark the tombs of the age of stone are found in prodigious numbers, and they are often truly gigantic works. The lacustrine establishment of Moosseedorf must clearly have lasted a very long time, judging from the quantity of bog which has been formed in the interval, and which has engulfed the remains of the industry of the age of stone. As to the numerous and often extensive lacustrine cities of the age of bronze, which have existed in the Lake of Bienne and in that of Geneva, they were scarcely constructed to be immediately abandoned.

The Danish savans estimate that the age of stone goes back at least 4,000 years, perhaps very much further. In fact, the appearance of man at an early date in the pine layer of the *Skovmose* invests him with a very high antiquity in Denmark, as we have already seen.

But such estimates cannot end in positive results. To arrive at dates in archæology it will be necessary to call in the aid of geology, just as no absolute chronological data in geology can be obtained without the assistance of archæology, starting from a sufficiently thorough knowledge of what has happened since the appearance of man on the earth. The two sciences are thus called upon reciprocally to complete each other.

The following is an observation of this geologico-archæological character, which has just been made in Switzerland.

**Cone of the Tinieres.**—The cone of torrential dejection (*Schuttkegel*, in German) of the Tinieres,<sup>1</sup> at the point where the material is cast into Lake Lemane at Villeneuve, is cut transversely by the railway excavation. The excavation thus made has laid open the interior of the cone for a length of about 500 feet and to a depth of nearly 23 feet. There was found here at four feet depth under the surface of the ground, quite regularly parallel to this latter and that over a great extent, both in length and width, an ancient stratum of from four to six inches in thickness, with angular fragments of Roman tiles, and with Roman coins somewhat defaced, but apparently anterior to the lower empire. At ten feet in depth under the modern surface of the ground, and

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<sup>1</sup> For information respecting this kind of formations see *A. Surell. Essays on the torrents of the Higher Alps. Paris, 1841, in quarto.* It is a very good work, only the *extinct cones* of the author belong to the diluvium, and not to modern formations.

also regularly parallel to the latter, over a great extent in length and width, there was found a second ancient stratum of six inches in thickness, characterized as belonging to the age of bronze by the presence of a well preserved metallic object,<sup>1</sup> and by angular fragments of the pottery of this epoch. Lastly, at nineteen feet in depth under the present surface, the superficial vegetable mould attaining at this point, owing to peculiar circumstances, a thickness of a foot and a half, there has been laid bare over another rather extensive space and still parallel to the general stratification of the deposit, a layer of ancient mould of the age of stone six or seven inches in thickness, with numerous angular fragments of very coarse pottery, and with abundance of charcoal and broken bones of animals, of which many had been gnawed by a carnivorous animal. Evidently man had lived on the spot, and during some time, for the charcoal was found in a still lower gravelly stratum, at twenty feet under the present surface of the ground.

It will not be out of place to notice that the three layers referred to, of four feet, ten feet, and from nineteen to twenty feet in depth, represent so many ancient layers *in situ*. For, if they had been formed and deposited by the torrent in the way in which they are found, the fragments of pottery which they contain would have been rounded, and not angular, and there would not be seen in them fragile shells of snails, perfectly intact and well preserved.<sup>2</sup>

Now, deducting three centuries for what has been caused by modern accumulations of soil, fixing the beginning of the Roman epoch in Switzerland at the commencement of the Christian era, and its end at 563 after Christ, the date of the land-slip of Tauredunum, that laid waste this vicinity, we come to admit that ten or fifteen centuries have been required to bury the Roman layer under three feet (exactly 0.92 meter, deducting 0.15 meter for the thickness of the Roman layer and 0.07 meter for the thickness of the sod) of torrential alluvium. We may also admit, considering the uniformity and regularity in the internal composition of the cone, that the latter had a tolerably constant ratio of growth, at least when we take in, as we do here, a series of many centuries. Only this growth must have gone on at a gradually diminishing rate, because the volume of a cone increases as the cube of its radius. Taking this circumstance into consideration, and assuming 900 feet, say 270 meters, as the radius of the present cone, (which is a minimum,) and four degrees as the inclination of its surface in the locality alluded to, (from forty measurements based on the levels taken by the railway engineers,) we arrive at an estimate of from twenty-nine to forty-two centuries of antiquity for the layer belonging to the age of bronze, and at one of from forty-seven to seventy centuries of antiquity for the layer that belongs to the age of stone. By the same

<sup>1</sup> Pincers—perhaps a depilatory—of molten bronze, of the style of the age of bronze, and preserved in the collection of Mr. Troyon at Eclepens.

<sup>2</sup> The museum of Copenhagen and that of Lund possess each a relievo model in plaster, representing the cone of the Tiniere with the excavation for the railway and the layers alluded to.

process of calculation, we should find from seventy-four to one hundred and ten centuries for the total age of the whole cone, and this is rather a minimum than a maximum.

The date thus found of the layer of the age of bronze does not disagree so much with what has been said of the antiquity of that of iron. As to the date of the layer of nineteen or twenty feet, if the age of bronze did last so long, as everything leads us to believe, how much time has not man required from the commencement of his primitive civilization to arrive at the bronze epoch! Must not the progress of mankind in its infancy have been extremely slow!

We may, perhaps, be surprised, that the intermediate layers of the torrential deposit did not also furnish antiquities. In the first place, there is nothing to show that the locality was constantly inhabited; on the contrary, it must occasionally have been abandoned for a long while, after the devastations of the torrent. Furthermore, it could only be exceptionally that the torrent, in spreading itself to the right or left, would allow the layer of vegetable soil, which had formed since the last breaking up, to remain. It must usually have begun by ripping it up and sweeping it entirely away; it was only when it covered it again suddenly with a fresh coating of gravel, brought down without too much impetus, that it was preserved. Thus the layers of the ancient mould are lost entirely as we approach the central axis of the cone, where the water has always acted with more violence, as is confirmed by the gradual increase in volume of the transported materials in this direction. At one point in this region there was found in the gravel, but still at a depth of ten feet, a hatchet knife of bronze somewhat oxydized, and a well-preserved bronze hatchet, which had, therefore, not been rolled about. Its weight had probably caused it to remain stationary, whilst the earth that surrounded it was carried away by the torrent.

It is needless to say, that no one of the ancient deposits alluded to represents the total duration of each of the corresponding ages, but only some portion of each of those ages. It might, however, happen that the presence of each of these ancient deposits was consequent upon so many embankments, which, by stopping the overflows of the torrent on that side, had allowed the mould to accumulate and attain a certain thickness. In that case, each of the three layers in question would indicate rather the end than the beginning of each of the corresponding ages. This is confirmed, as regards the layer of the age of bronze, by the fine workmanship of the bronze pincers, which were found therein, and which could not have belonged to the early part of that age. As to the layer of mold on the present surface of the soil, its slight normal thickness of two or three inches only, including the space taken up by the roots of the grass, proves that it is not of very ancient date.

The cone of the Tinieré has been for three years past the object of continued research, the details of which will be laid before the public. The results which have just been made out, appear tolerably satisfactory, but it will be necessary now to compare them with other facts of the same kind, obtained in other localities. At any rate, it is a singularly lucky chance to find thus layers of the three ages in the same excava-

tion; and the result obtained, however little positive and certain it may appear, is assuredly much better than the total absence of any data on the subject; and we must, therefore, be contented for the present with this approximation, for the want of a better one.<sup>1</sup>

A third memoir with plates, by M. F. Keller, at Zurich, on the lacustrine habitations will be published in the course of the month of March, 1860. It will contain a report in French on the lacustrine habitations of Concise and the neighborhood of Yverdun, by M. Louis Rochat; and another article, also in French, on the lacustrine habitations of Estavayer, by Messrs. Rey and De Vevey.

[In connection with this paper, which has been translated from a pamphlet presented by the author, we may mention that Frederic Troyon, of Switzerland, has also just presented to the Institution several copies of a very interesting work on ancient and modern lacustrine habitations.<sup>2</sup> This work gives a detailed account of the remains of the ages of stone, bronze, and iron found on the site of ancient buildings erected on the borders of lakes in different parts of the world.

After having collected and classified all the data relative to this subject, the author gives a summary of the conclusions which have been drawn from the facts.—*Secretary Smithsonian Institution.*]

<sup>1</sup> Objections against what has been said about the cone of the Tiniere have been raised in the discussions of the "Société Vaudoise des Science Naturelles." See the Bulletin of this Society of the 16th of June, 1858. But the opponent not having thought it necessary to verify the observations of the author, nor even to notice his numerical results, the latter considers himself excused from answering, except by silence.

<sup>2</sup> Habitations Lacustres des Temps Ancienes et Modernes, par Fredric Troyon. Lausanne, 1860.

## THE MICROSCOPE.

TRANSLATED FROM "AUS DER NATUR, ETC.," LEIPZIG, 1858, FOR THE SMITHSONIAN INSTITUTION, BY C. A. ALEXANDER.

It may be generally observed that those to whom the performance of a scientific instrument is not known through its proper use, are disposed partly to overrate, and again, in some other respects, to conceive too low an estimate of its effects; and this is no where more clearly seen than in regard to the microscope. Nor have we to seek far for the reason. The operations of the microscope have not been made known to the great public through the results of scientific research alone; while the costliness, and still more the difficult handling of the instrument have prevented it from becoming, like the magnet, and the electrical machine, a familiar means of "pleasant and instructive" amusement, by which it might have found its way into wider circles. So much the greater, however, has been its use, and often misuse, by itinerating showmen, whose interest it was to exaggerate to the utmost the marvel and strangeness of the object by which spectators were to be attracted. Numerous are the fallacies which have been thus scattered abroad. It may not be out of place, then, to attempt to convey more accurate views of an instrument to which descriptive natural science is indebted for the most important of its advances in modern times.

Microscopes, or, in the widest sense, the apparatus by which objects but slightly removed are made to appear larger than they really are, and the observer is enabled to inspect parts of them which are otherwise undiscernible, are of great antiquity. Archæologists are now agreed, however eloquently Lessing may have maintained the opposite opinion, that the ancients were in possession of magnifying glasses, without the help of which it would have been impossible that the exquisite work of their engraved stones could have been executed. Indeed, the wonder would be if it had been otherwise. Daily observation must have evinced to them, as it does to us, that transparent bodies with curved surfaces magnify objects which are viewed through them.

The physical laws on which this phenomenon depends are so well known, that we shall only briefly indicate them. Rays of light which pass from one transparent body into another of different density, from air for instance into glass, undergo a deflection from their original course, and are bent or refracted. Those proceeding from a remote object in parallel lines will, at the point of contact with a transparent body bounded by spherical surfaces, (a lens,) be bent in such a manner



that on issuing from it they converge, and at a certain distance behind it are collected into a small image of the object; the distance being so much less as the curvature of the surface is greater and the form of the lens approximates to that of a sphere. The place at which this image appears is the focus of the lens. If the body from which the rays proceed be placed in front of the lens at the distance of its focus, the inflection of the rays which fall upon the anterior surface in divergent lines, will cause them to issue on the other side in parallel lines. Move the object still nearer, so that the angle of divergence formed by the incident rays shall be greater, and the lens has no longer the power of rendering the transmitted rays parallel. They will only issue from it in lines less divergent than before.

The human eye is itself a lens which casts diminished and inverted images of observed objects on the retina, the membrane which is alone sensitive to the effects of light. To the distinct perception of small objects brought near to the eye, there is consequently a limit prescribed, since, through an undue approximation of the objects, the image into which the eye collects the rays proceeding from them, falls behind the retina. The distance between the object and the eye, from which this effect results, is different, according to the visual peculiarities of observers. Very near-sighted persons are able to see objects distinctly at three inches distance; consequently they see more of the details or single points of an object than the far-sighted; for it is altogether essential to the distinctness of any object that its image should have a certain extension on the retina. But this extension will be the greater, the wider the angle under which the rays proceeding from its several points strike upon the eye.

If we interpose now between a very near object and the eye a convex lens, the rays from the object pass through the lens into the eye in parallel or slightly divergent lines, provided the object be at the distance of the focus of the lens or somewhat nearer. The eye is now in a position to cast a well-defined image from the closely approximated object on the retina. The object, which in the case of the near-sighted must be situated nearer the lens, is seen, as if it were no further removed from the eye than the distance from the object to the central point of the lens: being thus seen under a wider angle of vision, it will of course appear larger.

The magnifying power of a lens depends, on the one hand, on the refractive properties of the substance of which it is composed. On the other hand, a lens will magnify the more strongly, the smaller the radius of the sphere, of which the curved sides represent points of the surface. In a sphere of crown glass the focus is distant from the surface about the fourth part of the diameter; in a double and equally convex lens, about the length of the semi-diameter of the sphere of which one of the sides of the lens represents a part. Such a lens, whose curvatures correspond to sections of a sphere of one inch diameter, magnifies, to a sound eye, about eight times. Were it of diamond, it would magnify twenty-one times, since the refractive power of the diamond is two and a half times greater.

There is no practical difficulty in providing lenses of a spherical

radius extremely small, and consequently of enormous magnifying power. We may obtain very small and almost exactly spherical lenses by drawing out a glass thread and melting off small drops from it. Globules thus obtained, and set in a fitting manner, afford a linear enlargement of as much as 2,000, (or if we accept the authority of the itinerant microscope-exhibitors, to whom we shall return hereafter, an enlargement of just 8,000 million times;) but this rate of increase has never been used or pretended to be used in scientific researches. In practice, to be sure, no limit as regards the magnifying power of single lenses is to be too strictly regarded: but a train of radical defects makes the profitable employment of such results as those just alluded to impossible.

The rays which impinge on the center of a lens and the points immediately around it are more slightly refracted than those which enter nearer the edge. The points at which the rays proceeding from an object are united do not coincide, but present a series of images lying closely behind one another. The image of the sun, received with a single lens, appears at the distance from the lens where the image is brightest and clearest (the focus of the rays falling in and near the center) surrounded by a visible fringe, the cause of which is, that the rays entering towards the edges of the lens, after crossing one another at their respective points of union, situated in front of the receiving surface, fall upon that surface in the circumference of the principal or brightest image. The name of *spherical aberration* has been given to this unequal refraction of rays transmitted through a lens. In like manner the rays passing through the lens will not be collected by the eye into a sharply-defined image. Those entering at the edge, fringe the image of those which have passed through the middle. The image of a small object is injuriously circumscribed, that of a large one distorted; inconveniences, which, with the progressively increased power of the lens, become at last intolerable.

The second inconvenience, increasing with the augmented power of single lenses, is, that objects seen through them appear surrounded by colored borders. A ray of white light, in consequence of being bent in its passage from one transparent body to another, is not symmetrically refracted, but separated into rays of different colors, whose refrangibility is unequal. Of the variously colored rays, into which white light thereby is resolved, the violet is most, the red least diverted from its original course. From the transmission of white light through a prism arises the well known seven-colored spectrum, whose red rays lie nearest, the violet farthest from the point, at which the prolongation of the original direction of the beam of white light would strike the surface on which the spectrum is formed.

By transmission through a lens the violet rays, in virtue of their greater refrangibility, will be collected into a focus nearer the lens, the red ones further off. As in consequence of the spherical aberration of light a succession of foci exists at different distances from the lens, the rays from the outer portions of the lens uniting nearer to it, those from the middle further off, so, through the separation of the white light into differently colored rays, a series of differently

colored foci is formed; the violet nearest, and successively, the blue, the green, the yellow, and so on. In whatever place of this series the image may be received, it appears encircled by colored borders, which proceed, according to the distance of the receiving surface from the lens, from the circumstance of the colored rays striking on that surface, either before their union into a focus, or after they have crossed one another therein. Only in the centre of the image of an intercepted white ray is seen the whiteness proceeding from the union and accordance of all the individual colors. All lines and points of a body viewed through a lens, have, on the other hand, a tinted bordering, so much the deeper colored and broader, the greater the curvature of the lens.

There are means for obviating in a great measure the effects of spherical aberration: we need only prevent the transmission of rays through the margin of the lens. But the so-called "diaphragm" employed for this purpose, the application of a metallic disk perforated in the middle in front of the lens, increased another inconvenience which had been before too sensibly felt in the use of strongly magnifying, and therefore greatly curved and small lenses. The pencil of rays passing through such a lens, is itself so small that a very limited space only can be surveyed. And since it can give only a very circumscribed portion of light to the retina, the use of small lenses is thus rendered extremely fatiguing to the eyes. Both defects are increased by the application of the diaphragm, setting aside that its employment is impossible in the smallest class of lenses.

The painful and laborious use of single lenses early gave occasion to a different form of the instrument. Here, however, it may not be out of place to say, that common usage gives to magnifying glasses, which, while they enlarge perhaps as much as thirty times, may, when disengaged, be readily managed by the hand, a different name from those which require a fixed frame, in order to keep them immovable at a determinate distance from the object: the former are styled in German, *lupen*; the latter, microscopes.

A double convex lens depicts, by means of the rays which pass through it from an object in front, an inverted image; a diminished one when the object is situated at more than its double focal distance, an enlarged one when it is brought nearer, but not so near as the single distance of the focus, for then no image is any longer formed behind the lens; all the transmitted rays still diverge. The image is so much the larger, and at the same time further from the lens, the nearer the object is approached to the focus on its anterior side.

The inverted image formed in this way by a lens is much larger than the apparent extension of the object viewed through the lens when the eye is closely applied to the latter. The former mode of observation also does not impose the condition of so near an approach of the object to the lens. Another related circumstance is, that a larger space can be observed at once than is the case when the lens is brought close before the eye.

The compound microscope, in its original form, consists of a tube, on the lower end of which is screwed the single lens which first receives the rays proceeding from the object to be observed. By a mechanical

contrivance the tube, and consequently the lens (called the object-glass) attached to it, may be adjusted and maintained at any desired distance from the object. The object-glass transmits into the tube an enlarged inverted image, which, by regulating the distance between the glass and the object, we can bring with accuracy to the upper end of the tube. Here it is viewed through a moderately magnifying lens (the eye-glass) to which the eye is directly applied. Instead of a single lens as eye-glass, the practice soon obtained of using a combination of two, arranged at something less than their focal distance from one another, which, being set in a brass cylinder, might be inclosed in the tube of the microscope. The lower and weaker of these two lenses causes the rays of the image transmitted through the object-glass somewhat to converge; it diminishes the image, but makes it brighter and sharper. This image is once more enlarged by the upper lens of the eye-glass. In the tube of the microscope and eye-glass perforated diaphragms are appropriately disposed, which exclude from the eye rays passing through the rim of the differently refracting lenses.

It was in this form that the second decennium of our century found the compound microscope. It was a very imperfect instrument. Its sole advantage over strongly magnifying single microscopes, over lenses of short focal distance to which the eye was immediately applied, consisted in a greater convenience of handling; an advantage more than counterbalanced by its lower optical efficiency. All the faults of single lenses in regard to the magnified images produced were still conspicuous in proportion to the enlargement. The colored bordering of the images still proved very annoying, and the narrowing of the aperture, occasioned by the diaphragms which intercepted the side rays, robbed the images of a large share of light. Besides, only weak object-glasses could be employed. Hence it was that several of the most distinguished microscopists continue to avail themselves preferably or exclusively of single microscopes.

Up to the time of the modern great improvements in compound microscopes, the most important observations and discoveries had been made with single microscopes, from the researches of Leuwenhoek, which led the way (first decennium of the eighteenth century) to those of Robert Brown, of whose striking discoveries we shall here only mention that which led him to detect a certain independent and oscillatory motion of small portions of organic and unorganic bodies floating in liquids.

The first step to these improvements was the elimination of the colored circles fringing the images of the microscope. The degree in which different transparent bodies refract the rays of light does not in all cases bear an equal proportion to that in which, in refracting, they separate white light into the colors of the spectrum. While crown-glass, for instance, strongly refracts the ray, it separates it into the different colors only in a moderate degree. Flint-glass, on the other hand, effects the prismatic dispersion in a much greater degree, while the refraction of the rays is not greater than in crown-glass. The optician has hence a means of preparing compound lenses, constructed of concave and convex lenses, which transmit the light almost without prismatic dispersion. If a convex crown-glass lens be joined with a

concave flint-glass one, whose curvature is such that its prismatic power equals that of the crown-glass lens, then, because the prismatic dispersion originating in the concave flint-glass lens counteracts that of the convex crown-glass lens in consequence of the opposition of their curvatures, the former annuls the latter. The image formed by the combined lenses, though its enlargement falls much short of that which the crown-glass lens alone would give, is on the other hand nearly colorless—*achromatic*. Not wholly so: from causes whose exposition here would lead us too far, there always remains a colored bordering; but it is scarcely observable, and for practical uses no longer embarrassing.

It is generally received that Fraunhofer was the first who (about the year 1811) adopted for microscopes this important improvement, which had long before been applied to astronomical telescopes. The Dutch, who assert for their countrymen the origination of so many inventions, claim also for one of them the honor of this, as well as of gunpowder and printing; and here, it would seem, with better right than in the case of Laurenz Kosur. It is credibly stated that about the end of the last century, Beedsnijder, an optician of Amsterdam, had prepared object-glasses of this kind of pretty good quality; Van Deyl very good ones about 1807.

Something was thus gained, but not a great deal. The Fraunhofer object-glasses gave no very considerable enlargement. The spherical aberration was still present, and necessitated the use of a narrow opening. The idea of obviating the aberration by the combination of several lenses, selected with a view to the counteraction of their respective faults one by another, was first carried into execution by Selligué, in 1824. This measure was of the most decided advantage. The spherical, and in great part the remainder of the chromatic aberration, could be now conveniently corrected, inasmuch as the distances between the successive, and in themselves nearly achromatic lenses could be experimentally adjusted, until the image cast by them should be infected with the fewest possible faults. The practical opticians pressed forward with zeal in the newly-opened path. Before all, Amici, in Florence; next to him the English opticians, Ross, Smith, and Beck; followed by the Dutch, Plössl, Schieck, Merz, the French Chevalier, Oberhäuser, offered and offers in this way instruments of high perfection, and far excelling in every respect the single microscope, with a faculty of magnifying those of Amici to the extent of 500, and the Dutch about 300 times, and with an unimpeachable clearness and sharpness. By further approximation of the object to the object-glasses, and lengthening the tube of the instrument, as well as by the employment of more strongly magnifying eye-glasses, the size of the image indeed may be increased, but not its distinctness. We see no longer, in the more enlarged image, lines and points as before.

These are the approximate limits of the working capacity of our present microscopes. An enlargement of more than 800 times can in no case be employed with advantage.

Opposed to the high figures which itinerant microscope exhibitors give out as the magnifying capacity of their instruments, the low ones we have stated will surprise many readers. In explanation, a few

words are necessary on the specific definition of the magnifying power of a microscope. To ascertain that power, let us observe through *the microscope* a scale minutely graduated on glass; it is not difficult for a mechanist, with the help of rulers moved forwards by means of fine screws, to graduate scales on glass plates with the diamond, whose single divisions shall be  $\frac{1}{700}$ , or even  $\frac{1}{1000}$ , of a line from one another. Let us fix near the microscope, at the distance before the eye of distinct vision, a scale proportionably divided, only more coarsely: let us say into lines. Commonly ten inches, or as well twenty centimeters, are taken as the distance from the eye. It may now be determined, by visual measurement, how many divisions of the fine and magnified scale apparently occupy the same space with the divisions of the larger scale seen with the naked eye. Let, for example, the fine scale be divided into hundredth parts of a line, and let two divisions of this scale, viewed through the microscope, occupy the same extent as eight lines on the scale seen with the naked eye: the microscope thus magnifies  $\frac{100}{8} \times 6 = 300$  times. This is the *linear* magnifying power of the microscope; and since it affords the simplest expression of the practical performance of the instrument, it is that which is usually specified by scientific observers. It is now plain, that a square  $\frac{1}{800}$  of a line in length and breadth, seen under such enlargement, will appear one line long in each direction; that thus on its surface, 90,000 squares, each  $\frac{1}{800}$  of a line in length and breadth would find room. The superficial enlargement by the instrument would hence be 90,000 fold. Instead of the square let us assume a cube with sides  $\frac{1}{800}$  of a line in extent, and through the 300-fold linear enlargement this cube would appear of such an extension that twenty-seven million cubes, of  $\frac{1}{800}$  of a line lateral measure, would be contained in it. The magnifying power of the instrument in respect to the whole mass is therefore 27,000,000 fold. In this way do the perambulating microscopists obtain their loud-sounding million-times-magnifying numbers. A hundred fold linear enlargement itself gives one million fold, two hundred fold gives eight million fold, cubic measure.

It is in the nature of things that the images of the most perfect existing microscopes, the compound, of which we have been before speaking, can be seen with but one eye at a time. A microscope, to serve for exhibitions, whose figures are to be seen by many persons simultaneously, must have an essentially different construction. The sun or hydro-oxygen gas microscope (they differ from one another only as regards the source from which the light issues) is, in essentials, similar in arrangement to the well known child's toy, the *Laterna magica*. The whole difference lies in the greater intensity of the light employed, and the careful management of the magnifying glasses. The rays of the sun received upon a mirror, or those from a cylinder heated to whiteness by the hydro-oxygen blow pipe, are thrown, after being concentrated by convex lenses, on the exhibited object: the rays proceeding from this now pass through a system of achromatic lenses, in all points equivalent to the object-glass of a microscope of the ordinary sort, composed of several lenses. Since the object is now placed somewhat more removed from the object-glass than its focal distance, there

is produced behind the object-glass a magnified inverted image, which received on a white surface from twenty to thirty feet distant, may be seen at once by any desired number of persons.

The sharpness and clearness of the images of a solar microscope, still more (on account of the less intensity of the light) of a gas-microscope, fall far short of those of the compound microscope. There are incomputably fewer of the details of an observed object to be perceived with the best solar microscope, with like magnifying qualities, than with an indifferent compound microscope. It were a great error to believe that, in reference to the practical adaptation of a microscope, we should take as a measure the greatest enlargement which it is capable of effecting. Incomparably more important is it that the microscope should exhibit the outlines of the observed object with the utmost possible sharpness, and the component details in the greatest possible number. Both requisites will be the better fulfilled, the more completely the spherical and chromatic aberration are averted through the adjustment of the coöperative lenses. In lenses for solar microscopes no optical artist has thus far succeeded in attaining the degree of excellence possessed by the optical part of the compound microscope. We shall presently return to the working capacity of the microscope as independent in certain respects of its magnifying power, and illustrate it by some examples. In the mean time let these suggestions suffice to show the value of the showman's statements, in cases where they conflict with the judgment of the scientific investigator. It should not, however, in dismissing this subject, be said, that among these itinerants there are not to be found qualified individuals, to whom, next to their gains, the instruction of the gazing public is not indifferent. But only too many charlatanisms of the worst kind are practiced. We remember an instance where the circulation of the blood in human hair was exhibited to the believing spectators and hearers; another, where the showman pointed out the movable thorn-shaped excrescence on the back of the common wheel animal, as its heart, which this remarkable creature carries about with it on a stake. And not one of these exhibitors of sun and gas microscopes, whom we have had an opportunity of seeing, but has presented to the crowd, as infusoria existing in every drop of water, the larvæ of gnats and even dragon flies—animals several lines in length, of which not only the outline but the separate parts are visible to the naked eye, and which only exist in standing water, rich in many other organisms; in water which swine, at all particular, would not drink. The spasmodic contortions of the death struggle of animals in the exhausted water were set forth as an example of the war of all against all, and if one glanced by another, that signified that it had devoured it. But let the drinkers of water take courage: We here record for their comfort, that in water which appears crystal clear to the naked eye, not even the microscope has been able to detect any sort of animal.

Microscopic vision differs chiefly from that with the naked eye, in that the instrument, in a great degree, refuses accommodation to the organs of sight with reference to distance. We see clearly through the microscope only the parts of the object lying in a determined hori-

zontal plane. To see other parts clearly, the distance of the inner apparatus of the microscopic tube from the object must be altered. The observer has to construct the form of the observed object in his mind from a succession of different images thus obtained. This is soon learned: other circumstances however there are, which render microscopic investigation so difficult and particular, that it requires long continued use for the practical mastery of the instrument.

The higher the degree in which an object is magnified, the weaker is the illumination. Even with a hundred fold linear enlargement, a body in ordinary daylight appears as if in deep twilight, and the minute particles of its surface are no longer to be distinguished. Nor is the matter bettered by illumination with the direct rays of the sun, collected perhaps through a lens. The light can then only be thrown upon the object lens in a very oblique direction, since this lens, where a greatly magnified image is to be produced, must be brought very near to the object. Small prominences spread deep shadows over the surface. Shining spots reflect the light with embarrassing effect. For practical research, where great enlargement of the object is required, we must have resort to an expedient for evading these difficulties: the object to be observed must be rendered transparent or translucent, and be lighted from beneath, so that the rays may pass through it into the microscope and thus into the eye. This will be most conveniently effected by placing the object on a glass plate over the tubular frame of the microscope, under the opening of which a movable mirror is placed. With this we collect the light, and the mirror is so directed that it throws a fascicle of reflected rays through object and instrument upon the eye.

There are no organized and only a limited number of unorganized bodies which are absolutely opaque. Thinly separated layers allow the light to pass sufficiently for the microscopic examination of a body. It is an essential preliminary with microscopists, if the structure to be examined be not in itself simple and conspicuous enough to make this unnecessary, to prepare the object for examination by means of light passing through it. Small organs are to be separated and stripped of the enveloping textures. Of larger and more complex structures, the thinnest possible sections must be taken. Often there are parts to be dissected so small that the unaided eye cannot perceive them. Their division under the microscope has to be effected with the finest pointed and edged instruments. Scarcely anywhere is Franklin's saying so applicable as to the manipulations thus rendered necessary: "A natural philosopher must, at a pinch, be able to bore with the saw and to saw with the auger." As the compound microscope shows the images inverted, the preparations which are to be gone through with, by means of needles and knives, are highly incommodious. To remedy this, we commonly use either a single microscope, or else a compound one whose eye-glass represents a smaller compound one. The image, twice reversed, now appears upright.

It is not the difficulties here indicated which have procured for microscopic observers the reproach, but too well deserved, in earlier times, of unreliability. Had observers always prevailed upon themselves rigorously to separate what was really seen from what was only con-



jectured, and to have delivered matters of fact without adornment, it would never have come to pass that Linnæus himself, and his school after him—a school of so much influence and for years exclusively dominant in descriptive natural history—should have put the microscope, so to speak, under the ban, and have looked with indifference or scorn on the painstaking labors of inquirers who employed that instrument. It may be some offset to this, that, in later times, microscopists have been by no means backward in repaying to non-microscopists this disparaging estimate with interest. The propensity to piece out the chain of observed facts by conjectures is too deeply grounded in human nature not to operate strongly in a department where but few and isolated laborers were to be found—so few, that the most effective restraint, the objections of rival cotemporary inquirers, was almost wholly wanting. Even the earliest leaders and guides could not keep themselves free from sophistications of this kind. To give but one example: Leuwenhoek asserted, in the most positive manner, that the corpuscles of the blood, (whose real organization as somewhat flattened globular cellules is clear at the first glance with our present instruments,) are each of them composed of six spherical polygons, made so by reciprocal pressure on their touching sides; and that each of these again consists of six similarly shaped smaller spheres, and so on to infinitude. This view has not only been set in the clearest light by frequent republication, but a certain English writer has drawn it out in still greater detail as one of the most striking proofs of the infinitely divisible constitution of organized bodies. Such fallacies were once long lived. But since the middle of the third decennium of our century the number of skillful microscopists has been so great that nothing of the kind could possibly have been asserted without immediate contradiction. Microscopical errors, defended with the utmost skill, pertinacity, and recklessness, have not in later times maintained their ground for more than a few years.

The very copiousness of the subject admonishes us to be brief when we speak of the effect of the microscope on the development of the descriptive natural sciences. The microscope opened to us, not less than the telescope, a new world, and every improvement has permitted us to push further back the limitary boundaries of our knowledge. Still more than for an acquaintance with a countless number of animal and vegetable existences, which had before lain beyond the bounds of our sensible perception, are we indebted to the microscope for the disclosures which it makes of the exquisite internal structure of living beings and unorganized bodies. Yet must we not rate too highly the knowledge thus obtained: it is more an extension in breadth than in depth. The instrument has put it in our power to perceive with the senses a multitude of heretofore hidden phenomena which accompany organic existence. But these experiences have only indirectly and but little advanced us in a knowledge of the primitive forces which determine the conditions of organization and of life. Towards this goal of physical research, the assignment of the complicated play of the constructive and destructive forces of nature to their several factors which refuse all further investigation, it advances us a little way only,

when we have learned the construction and the single parts of the machines which are set in motion by those forces, however necessary this preliminary knowledge may be to further research. And to procure us more than this preliminary knowledge the microscope is powerless.

# SCIENTIFIC CONGRESS OF CARLSRUHE.

BY M. J. NICKLÉS.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION, FROM THE MEMOIRS D'ACADEMIE  
DE STANISLAS, NANCY, 1859, BY C. A. ALEXANDER.

## I. SCIENTIFIC ASSEMBLIES OF GERMANY.

A meeting of professors of science and of medicine, which took place at Leipsic, September 18, 1822, laid the foundation of those scientific assemblages of Germany which have been since known by the title of "the Association of German Savants and Physicians." These assemblages are held annually; and being open, without distinction of nationality, to all men of science, we have hence enjoyed the privilege of taking part in that which was convened in the course of the present year, 1858, at Carlsruhe, the capital of the Grand Duchy of Baden.

Whether considered with reference to the persons who composed it, the labors communicated, the ideas suggested for consideration, or the enthusiastic reception accorded to the members both by court and people, this thirty-fourth reunion of the association is admitted, without contradiction, to have been amongst the most brilliant and memorable which has occurred. Before proceeding, however, to give an account of the transactions of the late meeting, it may not be without interest to recite the statutes under which the organization has been advanced to so high a degree of vitality and usefulness.

### STATUTES.

1. The object of the association is to afford to the scientific and medical inquirers of Germany an opportunity of becoming personally acquainted with one another.

2. Whoever in the domain of medicine or the sciences of observation has given the results of his labors to the public, is recognized as a member, and every one who is engaged in such studies may procure himself to be inscribed as such. A mere *inaugural thesis*, however, is not in itself regarded as furnishing a title to be enrolled as a member.

3. The association makes no special nominations and bestows no diplomas.

The right of voting pertains to those only who are actually present at any session; and decisions are to be determined by a majority of voices.

4. The meetings take place once a year; they are public, and, commencing the 18th of September, are to be continued several days.

5. The place of meeting is migratory; at each reunion the city shall be designated where the next is to be held.

6. Business affairs shall be conducted by a general agent (*Geschäftsführer*) and a secretary, inhabitants of the city designated, and shall be charged with the control till the next meeting.

7. The general agent shall designate the place and hour of the sessions and determine the order of the day; he should receive timely notice from all those who propose to address the meeting. The Secretary is charged with the protocol, with the accounts, and the correspondence. To these two functionaries are intrusted all signatures in the name of the association.

8. It shall be their duty to advise the authorities of the city designated, and to give due publicity to all which shall be determined on. If the nominations to these offices, which shall be made in advance at each meeting, be declined, those already in office shall have the power to appoint others, and may, in case of necessity, designate a different place of meeting from that chosen by the association itself.

9. If either of these two functionaries should die, the survivor shall nominate a successor, and in case of the death of both, the nominees for the year following shall at once assume the control of affairs.

10. The association shall possess neither collections nor property of any sort. An object presented at any of the sittings shall be returned to its owner. The accruing expenses shall be provided for by an assessment made with the consent of the members present.

More than nine hundred persons, who had inscribed their names on the list of the secretary, took part on this occasion in the labors of the sections or the fetes given in honor of the Congress. Quite naturally, a majority of these were natives of the country, not more than a hundred strangers being present, of whom the greater part were French, owing doubtless to the proximity of Carlsruhe. Of English savants there was an entire deficiency.

Paris was represented by a number of learned men, at the head of whom we remarked M. Despretz, of the Institute, professor of the faculty of sciences, and M. Wurtz, professor of the faculty of medicine. Alsace had sent its principal representatives, among whom MM. Daubrée, Lereboullet, Schimper, and Bertin were present from the first day, together with MM. Opperman, Kirschleger, and Kopp, of the school of pharmacy. The learned professor of chemistry from the same province, M. Kuhlmann, gave in the course of the sessions some of the principal results of his ingenious applications of chemistry to industrial purposes. Nor, among French savants from more distant places, can we pass by M. de Caumont, founder of the scientific reunions of France, or Dr. Duchenne, from Boulogne, who gave, in the French language, his researches on the treatment of certain maladies by means of *faradisation*, a new word, designating currents of induction as applied to therapeutics. As little possible is it to neglect the name of M. Ruhmkorff, the skillful constructor of Paris, who,

however, arrived too late to exhibit to the greater number of the physicists, already departed, the beautiful apparatus of induction which he had brought with him, whose effects considerably surpass those of the apparatus which he had presented on the occasion of his competition for the prize of the electric pile, and which had procured for its author well-merited encouragement and a prize of the Academy of Sciences.

The Congress was formally opened Thursday, October 16, at half after ten in the forenoon, in the presence of their royal highnesses the Grand Duke and Duchess, at the botanic garden of the Orangery, a magnificent structure decorated for the occasion, and surmounted by the national flags of the different savants present at the Congress. After addresses of welcome and inauguration from the "Geschaeftsfuhrer," Drs. Eisenlohr and Volz, one might have expected that the general session would have been adjourned in order to proceed to the installation of sections and the formation of bureaus; but, though the thermometer marked 104° Fah., and the heat, as well as the fatigue of their recent journeying, greatly incommoded the assistants, first one and then another, and finally a third orator were to be listened to, descanting on the generalities of science, chiefly on the question so much debated, of the alliance of faith with reason, until those present, who under other circumstances might have been disposed to acknowledge the great ingenuity with which the topics were treated, found themselves in the situation of men who, worn down in body and mind, aspire only after an adjournment which seems forever to flee before them like a *mirage*. Meanwhile the Orangery was crowded, and a heavy atmosphere, of which the orator alone seemed insensible, weighed upon the auditory. Still their royal highnesses maintained their place, and alone appeared to share nothing of the general fatigue, though the Grand Duchess had been obliged to have recourse to her parasol as a shelter from the solar rays.

This continued till three in the afternoon, when we were, at last, at liberty to withdraw to our respective sections; the bureaus were formed, and the order of the ensuing day was arranged.

The first day was terminated by a banquet, followed (by order of the government, and in honor of the members of the Congress) by a representation of the *Antigone* of Sophocles. Similar alternations of scientific conferences with festive reunions, of which latter, it may be said, that they were allowed to trench to too great an extent on the precious time due to the former, occupied the succeeding days of the Congress. Thrice only was a general session convened, on which occasions the author was too much occupied with the special pursuits, in which he bore a part, to attend, and shall only mention that, in the second of these sessions, Königsberg was designated as the place of assemblage for the year 1859.

Having given these details, as characteristic features of the late Congress, we gladly pass to a consideration of its labors.

The group of sciences represented on this occasion was divided into ten sections, in the following order: *Geology and mineralogy; Botany and vegetable physiology; Mathematics, astronomy, and mechanics; Physics; Chemistry; Anatomy and Physiology; Zoölogy*, (this science,

in consideration of the small number of zoölogists present, coalesced with the section of anatomy;) *Medicine; Surgery; Ophthalmology and gynecology; Psychiatrics.*

The transactions which we propose for special notice on this occasion are those of the fifth and sixth sections, (physics and chemistry.) These two sections held their meetings in the amphitheatres of the Polytechnic Institute, a vast establishment, frequented annually by more than 600 pupils from different parts of Germany and the Scandinavian islands, but whose buildings are not yet sufficiently spacious for the reception of all the collections. The largest part is assigned to chemistry, which, under the superintendence of the learned professor, M. Weltzien, forms a very important portion of the course of instruction at the Institute.

In what follows will be found a sketch of the principal facts submitted to the sections, whose proceedings we have undertaken to report.

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## II. SECTION OF CHEMISTRY.

A Solvent of Cellulose and of Silk—Apparatus for Preparing Ozone—Anemonine and Anemonic Acid—Preservation of Wood—Solubility of Sulphate of Barytes.

The presidents of this section were successively MM. Leibig, Woehler, Schoenbein, and Rose; under the former of whom, during the first day's session, the following communications, in the order here given, were submitted:

*M. Schlossberger, Professor at the University of Tubingen.*—The province of this savant is animal chemistry, which is indebted to him for numerous and interesting observations. His discourse on this occasion related to the reagent of Schweitzer, the ammoniacal oxyd of copper, which possesses the curious property of increasing the bulk and dissolving both cellulose and silk. M. Schlossberger has ascertained that the ammoniacal oxyd of nickel exerts, to a certain extent, the same property with reference to silk as the reagent with a copper base; only, in the case of the latter, the solution of the silk retains the blue color, while it is of a yellowish brown when treated with the nickel.

The cupro-ammoniacal liquid dissolves neither gum nor dextrine, but it readily dissolves the filtering paper. The salts, and more especially the alkaline salts, precipitate this solution of cellulose; the precipitate offers no trace of organization or crystallization, its centesimal composition not appearing to differ from that of the cellulose.

The same alkaline salts do not precipitate the solution of silk; hence we have the elements of a process for separating silk from cotton. A neater process, however, is based on the employment of the ammoniacal oxyd of nickel, which, as we have seen, dissolves the silk, but is absolutely without action on the cellulose.

The solution of cellulose is equally precipitated by alcohol, by a concentrated solution of honey, of gum arabic, or of dextrine. Schweit-

zer's reagent is without action on the pyroxyline or gun-cotton, as well as on collodion.

*J. Nicklès, Professor of the Faculty of Sciences at Nancy.*—On researches respecting fluorine, its presence in sulphuric acid, in blood, bones, teeth, in mineral and ordinary waters, the sources from which the animal organism derives it, and on the causes of error which infect the old process, with the means of avoiding those errors, &c. *Memoirs of the Academy of Stanislas*, 1857, p. 77; *Comptes rendus de l'Académie des Sciences*, T. XLV, p. 331; *Journal de Pharmacie et de Chimie*, T. XXIV, p. 113.

An interesting discussion took place in reference to this paper in which several chemists, particularly MM. Liebig, Erdmann, and Fritzsche of St. Petersburg, bore a part.

*De Babo, Professor at the University of Fribourg, in Breisgau.*—Apparatus for preparing ozone. This apparatus, by which ozone is obtained through the combustion of phosphorus, accomplishes the separation of the gas from the phosphorus acid with which it is usually contaminated. This result is obtained by causing the fluid to pass into a solution of chromic acid, which acid does not restrict itself to the oxydation of the phosphorus acid, but, as M. Baumert, a pupil of M. Bunsen, had already perceived, it also enriches the ozone, since after the washing the ozone is found to be surprisingly increased, obviously because the oxydation of the phosphorus acid is itself a cause of *ozonization*.

M. De Babo has succeeded in desiccating ozone to the extent of obtaining it in an anhydrous condition, whence it follows that ozone, or at least this particular species of ozone, cannot be confounded with the hydrogenized ozone discovered by M. Baumert.

MM. Bunsen and Magnus, who gave their views on this occasion, are of opinion that it is necessary to recognize two species of ozone, the one to be regarded as allotropic oxygen, the other as a hydrogenous combination. We shall see presently that this obscure question of the nature of ozone received considerable elucidation at one of the subsequent sittings.

*Erdmann, Professor at the University of Leipzig.*—The name of M. Erdmann is of interest to us, not only account of the honorable labors which it signalizes, but because the savant who bears it was also the first master of the unfortunate Gerhardt. It was he who had the merit of presaging the future chemist, and of initiating in science the eminent man who died so young, and who had opened to chemistry so wide an horizon. It was into his own house at Leipzig that M. Erdmann received the young commercial traveler of Alsace, whom an irresistible inclination allured to the science, though somewhat, it must be confessed, to the detriment of those mercantile interests in which he had been engaged.\*

The occasion might justly be deemed fortunate which led us to make the personal acquaintance of the first master of our lamented friend, and enabled us to obtain information on some of the obscurer incidents

\* See biographic notice of Gerhardt, *Silliman's Journal of Sciences*, Vol. XXIII, p. 102.  
*Author.*

of his youth and scientific career. The oral lecture of M. Erdmann brought to the notice of the section several new facts verified in his laboratory:

First. *Vesicatory Principle of the Ranunculus Sceleratus*.—This principle presents itself under the form of an acrid oil which, in the end, changes into a white mass composed of *anemonine* and of *anemonic acid*. This transformation takes place in the plant even when subjected to desiccation, and the vegetable, in consequence of it, loses all its acrimony.

Second. *Action of some Metallic Salts on Ligneous Substances*.—It is a customary practice to preserve wood, and especially the sleepers of railways, by impregnating them with certain metallic solutions, and among others, the solution of sulphate of copper; for these saline substances form with the wood a species of combination which appear sufficiently intimate to resist the action of water, and wood thus prepared may, in effect, be sunk in water without abandoning to it the copper which is held in combination. Now, this is not the case when, instead of wood in its normal condition, we employ *purified wood*; that is to say, cellulose. Impregnated with sulphate of copper, the cellulose becomes colored, indeed, but at the slightest lavage with water, it resigns the sulphate which it seemed to have fixed.

Examining this fact a little more closely, we recognize that, in order that wood should be capable of fixing the sulphate of copper, it must necessarily be *resinous*. Moreover, it is known that weak solutions of the sulphate of copper remove azotised substances from wood.

Third. *Solubility of the sulphate of baryta*.—The sulphate of baryta is one of the salts on which water has the least action; but if this sulphate is insoluble in pure water, it becomes soluble when this last contains nitrate of ammonia; a concentrated solution of that salt even dissolves considerable proportions of it. This solution remains limpid in presence of the chlorides of potassium, of ammonia, of strontium, and of calcium, but it is rendered turbid by salts of which the base is baryta. Water added, even, in great quantities, has no action on it. This solubility of the sulphate of baryta in the nitrate of ammonia is considerably augmented when we add to this last a little chlorhydric acid; in which case the dissolving agent is the chlorine, resulting from the decomposition of chlorhydric acid.

From the fact that at this first sitting of the section the list of designated speakers was small, an opportunity was afforded for objection, and several lively and instructive discussions arose on the part of the members; but from the 18th of September, the order of the day being fuller, and the sessions restricted to two hours, little questioning could take place, and the speakers, whose names had been enrolled, were required to succeed one another with as much rapidity as possible.



## III.

New Hydrocarburets—Picric Combinations—Industrial Processes—Different Species of Oxygen—Science and the Metrical System—International Relations and the Metrical System—Standard Liquors.

At the second meeting facts of great importance were communicated by MM. Fritzsche, Kuhlmann, Schoenbein, and Mohr. The first exhibited several new hydrocarburets which he had discovered in the tar proceeding from the distillation of wood; and adverted to a characteristic property of certain hydrocarburets of forming definite combinations with picric acid. This property, equally a discovery of the Russian chemist, will be found described in a French publication, the "Journal de Chimie et de Pharmacie," 1858, vol. XXIV, p. 158.

The novel facts brought to the notice of the association by M. Kuhlmann, were the result of inquiries having their origin in the desire to render salubrious a form of industry which has heretofore been the reverse, the fabrication, namely, of artificial soda, after the process of Leblanc. In this pursuit the transformation of marine salt into the sulphate of soda gives rise to streams of chlorhydric gas, a part of which diffuses itself in the atmosphere, which it renders unwholesome to animals and even plants. We need not speak of the attempts made, up to this time, to remedy this state of things, but we can certify that M. Kuhlmann has succeeded so well that he draws benefit and profit from it. Hence he was induced to give his process at length, that it may be available to all. In few words this process is as follows:

In the current of the acid gases, he places lumps of the carbonate of baryta, which occurs in masses in the mineral kingdom. By the action of the chlorhydric gas, the carbonate is decomposed, and is replaced by a useful product, the chloride of barium, which, by means of sulphuric acid, may be easily transformed into sulphate of baryta, a substance much in request at present, and of which M. Kuhlmann himself manufactures 2,000 kilogramms a day.

An improvement is adopted the moment the manufacturer finds his account in doing so, and such will be the case with this process, which will supply the means of disinfectment for many localities. It is not meant that the carbonate of barytas alone is available under such circumstances. At no distant day, when the chloride of calcium shall have undergone proper applications, this carbonate may be advantageously substituted for the other.

Another new fact which M. Kuhlmann had realized, relates to the employment of a residuum of a different kind, but at least as insalubrious as chlorhydric gas; the masses, namely, of chloruret of manganese, resulting from the manufacture of chlorine, which accumulate by millions of litres around the workshops, without a possibility of being conveniently gotten rid of; for there can be no question here of discharging the accumulations either into the river or the subterranean conduits, whose waters would be thereby rendered unwholesome. We may add that this residuum of the chloruret of manganese retains a sufficiently large proportion of chlorine to make the economizing it an object of importance: since, in France alone, the waste of chlorine in

this way amounts, in point of value, to something like two millions of francs per annum.

M. Kuhlmann proposes two modes of employing this residuum: one by transforming it into chloruret of barium by means of carbon and the sulphate of barytes; the other by treating it with another embarrassing residuum of the soda manufactures, the oxysulphuret of calcium, from which M. Kuhlmann obtains sulphide of manganese and chloruret of calcium.

The last mentioned chemist was followed by M. Schoenbein, the discoverer of ozone, who, as he himself stated, has been occupied for twenty years with the study of oxygen, and who furnished us, in the results at which he has arrived, still another instance of the fact that in science a noble reputation may be achieved even when the inquirer restricts himself to the observation of a single body. We must observe, however, that the new phenomena detailed to us on this occasion, imply a degree of sagacity which doubtless does not fall to the lot of every observer.

Mr. Schoenbein began with informing us that there are three kinds of oxygen, of which one, the common oxygen, is that which we respire in the air. The two other kinds constitute two species of ozone, which with reference to one another are as the two species of allotropic electricity, &c. We regenerate common oxygen when we place these two species of ozone in contact, and, on the contrary, we destroy it when by a given chemical agency we separate one of the two modifications. This tendency, on the part of these two modifications, to produce common oxygen, explains certain effects called catalytic, and which had till now remained unexplained; thus, the peroxyde of barium and oxygenized water rendered acid by means of nitric acid, reciprocally decompose each other in giving place to water, oxyd of barium, and common oxygen: under the same circumstances, the permanganate of potassium is reduced to manganic oxyd, the chromic acid becomes the oxyd of chrome; that is to say, these compounds are deoxygenized in presence of an abundant supply of oxygen, and precisely at the contact of that particular species of oxygen, ozone, whose burning power is effectual to oxydize directly the least oxydizable bodies, such as azote.

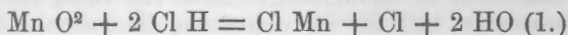
Effects apparently so contradictory are to be explained by what we have said above; a combination highly oxygenized may be resolved in presence of another compound rich in oxygen, whenever one of these compounds contains oxygen which may be termed positive and the other that which is negative. The result of such decomposition is ordinary or neutral oxygen. A like result is had when we agitate with oxygenized water ozone obtained with phosphorus; the product is nothing else but pure water, and common oxygen.

That ozone, then, or nascent oxygen prepared with phosphorus should act energetically as an oxydizer, it is not necessary that it should be in presence of the oxygen arising from the oxygenized water.

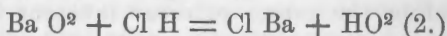
Since, according to the experiments of M. Woelher, there is required an equivalent of oxygenized water to decompose an equivalent of peroxyde of manganese, it may be said that, just as an acid loses its acid

properties in presence of a base, and *vice versa*, so likewise does ozone affected with the sign + for instance, lose its oxydizing properties in presence of ozone affected with the sign —.

This polarity of the different states of chemical activity in which oxygen may present itself, results still more from the manner in which certain oxyds act in regard to chlorhydric acid. In this case the peroxyde of manganese is replaced by a protochloride, chlorine, and water.



With the peroxide of barium, on the contrary, we obtain not chlorine, but oxygenized water.



To the group of the peroxyde of manganese are referable the peroxides of lead, silver, nickel, cobalt, bismuth, and vanadium; to that of the peroxide of barium pertain the peroxides of calcium, strontium, &c.

M. Schoenbein calls the former *ozonides*, the latter *antozonides*.

The *ozonides* do not give oxygenized water; in presence with it, they occasion a disengagement of common oxygen, and are decomposed in decomposing the oxygenized water. They color the tincture of guaiacum, blue.

The *antozonides* do not decompose oxygenized water; and do not give the blue tint to the tincture of guaiacum. On the contrary, they discharge this blue tint when it has been communicated by an *ozonide*.

In fine, the views here given, which assign to the *ozonides* a polarity distinct from that of the *antozonides* may be considered as being established by the fact that the former are, beyond question, electro-negative in reference to the latter.

One of the great international questions which is of constant recurrence, and which calls for a solution, attaches itself to the subject of weights and measures, the difference of which in different countries occasions no little embarrassment to commerce and to travelers. Several States have already adopted the metrical system; others would do the same if this system had been invented elsewhere than in France. Now, while such States lag behind through an inexcusable and short-sighted prejudice, science, which is of no country, has long since exchanged the pound, the ounce, the dram, the inch, the foot, the ell, for the gramme and its derivatives, the metre and its multiples or submultiples; so that it is very rare to find a grave scientific treatise, English or German, which has not substituted the metrical system for those irregular weights and measures.

This species of scientific revolution took place in Germany towards the year 1830; and in bringing it about, none was more influential than the man who has so largely contributed to shape the scientific destinies of his age, M. Liebig, with whom we may associate M. Woehler: by introducing, after the example of the French chemists, the metrical system into their laboratories, their publications, and consequently into the *Annalen der Chemie und Pharmacie*, their recognized organ, they have naturally imposed the use of that system on their

pupils and gradually also on their readers. Younger than they, and coming after them, M. Mohr has still borne an important part in the movement; his judgment and sagacity have availed to smooth the chief difficulties which attended it. The reader who is unacquainted with German may consult the excellent translation of the treatise of M. Mohr on volumetric analysis, which has been executed by M. Forthomme, a professor of the Lyceum of Nancy.

Now, the lecture of M. Mohr, delivered at the third sitting of the section of chemistry, had for its object the discussion of a question which connects itself alike with the metrical system and with analysis by means of standard liquors. The point aimed at here was effectively the determination of means for passing readily from weights to volumes, while avoiding the causes of error inherent in these delicate operations.

If, in effect, analysis by volumes, or, to employ the established expression of Descroizilles and Gay Lussac, the originators of this method, if standard liquors (*liqueurs titrées*) enable us to dispense with the use of the balance, and to assign proportionate quantities in fewer minutes than the process by weights required hours, it is easily comprehended that too much attention cannot be accorded to an operation which touches on the corner-stone of the edifice: *the transformation of weights into volumes, and vice versa.*

Our limits so much the less allow us to report the very technical procedure of M. Mohr, that it would be with difficulty understood without the use of figures; the reader who is interested in it will in all probability find it described in the second and forthcoming volume of the *Traité d'Analyse*, which the learned professor has ready for the press.\*

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#### IV.

Experiment in Acoustics—Iron Reduced by Hydrogen—The Society of Physics of Frankfurt—A Property of the Corneous Substance of Quills—A jet d'eau Serving as an Electro-scope—Questions of Priority—Scientific Rivalries—The Electric Spectrum—Silicated Hydrogen.

At its third sitting, the section of chemistry united itself with that of physics, and the meeting took place at a later hour than usual, in consequence of the previous day having been occupied with an excursion to Baden-Baden, where the Congress was received and entertained by the city. The sitting, of which we are now to speak, which was attended by many persons of high station, was specially devoted to experiments, many of which were calculated to interest even unscientific spectators. Of this description was one by M. Dové, professor in the University of Berlin, which consists in producing from a vibratory

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\* The translation of the first volume having been executed by Prof. Forthomme (8vo, with plates in the text, price 7f. 50c. : Nancy; Grimblot & Co.;) the second volume will be forthcoming given, by the same translator.

tuning-fork, suspended above a glass balloon containing a quantity of water determined by experiment, a distinct sound, capable of being heard throughout the hall of audience. The balloon must not be full, nor ought the fork to touch it; the instrument is simply held with the hand and in the prolongation of the neck of the balloon. The sound emitted depends on the position of the two branches of steel in reference to the neck of the balloon, the perception of the sound being very distinct when the plane of these two branches is in the axis of the neck, but none at all when the plane is perpendicular to it.

These facts had been recognized by M. Dové while engaged in researches to ascertain whether the ear which receives during a certain space of time some determinate sound becomes insensible to that sound, as the eye which has been fixed for some time on a certain color becomes insensible to that color. It might be said that the eye becomes habituated to the color, as the sense of smell becomes habituated to certain odors.

The analogy which exists between acoustic vibrations and those of light is borne out in this respect, inasmuch as M. Dové has satisfied himself that the ear may in effect be habituated to a sound to the extent of no longer perceiving it, after having been subjected to the impression for a time more or less protracted.

Iron in a state of great comminution, as we obtain it, where one of its oxyds is reduced by hydrogen, has for some time been employed in medicine. Well prepared, this reduced iron is so oxydizable that it kindles spontaneously in the air and burns with vivid sparks. Now, there has lately been established in the Tyrol a factory in which iron in powder is produced, having a considerable degree of tenuity, although the pulverization is effected mechanically and, as it would seem, with very delicate files. Experience has not yet pronounced with respect to the therapeutic properties of this product; neither does it burn spontaneously in the air, although it is extremely combustible, as was proved by an experiment which M. Magnus exhibited in the presence of the meeting. When a flame is applied to these filings they do not kindle; but they burn readily when previously suspended to the poles of a magnet. The experiment, which is quite a pleasing one, is easily conducted: there needs but to plunge the magnet into these filings, when they group themselves around the poles and remain suspended, forming a sort of beard, to which, if a match is applied, combustion immediately takes place and progresses rapidly. If we then shake the magnet, a multitude of sparks will be detached, being the particles of the iron in a state of combustion.

This property seems to pertain exclusively to these filings from the Tyrol, for I have ascertained that iron recently reduced possesses it in a very slight degree, and that the same iron, after having been prepared for some time, will have entirely lost its pyrophoric quality.

At Frankfort-on-the-Main there exists a species of scientific association, the *Physikalische Verein*, composed in great part of men of the world, who meet twice a week, for the purpose of keeping themselves abreast of the progress of physics and chemistry. The expenses of the association are provided for by an annual assessment of ten florins on each member. Science is here expounded by M. Boettger, than whom

none could be more competent, especially as the object is not so much a course of methodical instruction as the exposition of unconnected facts, supported by experiments aptly chosen and dexterously executed. It is in this line that M. Boettger particularly excels, for an extraordinary and peculiar facility seems to qualify him for the contrivance and execution of the most difficult experiments, without the necessity of a previous theory or system of ideas. Thus, in 1847, he prepared gun-cotton before the secret of its preparation was known, and without any other guide than the name of *fulminating cotton*, or other starting point than the xyloidine or nitrous fecula discovered by Braconnot. We may add that he made no secret of his discovery, but hastened to give it to the public. In like manner, having heard, some years afterwards, as all the rest of the world did, of the decisive experiment by which M. Faraday had discovered the action of an electro-magnet on polarized light, M. Boettger repeated the experiment with success, and published the manner of operating before the process which had been followed by the illustrious savant of England was known.

As M. Boettger is an assiduous frequenter of scientific reunions, he has often afforded them entertainment by attractive experiments, and by a dexterity of hand which might have won success even on a different stage. A simple exhibition of his, during the present session, seems not unworthy of notice. Having taken a goose quill, he pressed it down so as to bend it together in several places. The quill was not broken, but there were evidently folds; nor was it capable of being held upright and rigid as before. But a few manipulations by the operator quickly restored it, so that no trace of the folds recently so conspicuous, remained. The explanation is, that the quill had been first immersed for some moments in hot water and then plunged into cold; and the theory on which the result depends is, that the sudden contraction sustained by the corneous substance, previously distended by the warm water, enables the quill to recover its original rigidity. This process might doubtless be of service in restoring plumes used for personal decoration.

At the same session Mr. Boettger showed that a slender jet of water may serve as an electroscope. If a glass rod, which has been previously rubbed with a piece of cloth, be presented to such a jet, the thread of water is seen to change its form. If the rod approaches it from above, the small drops unite and fall in large drops; if, on the other hand, the rod is presented near the base, the height of the jet is diminished.

This experiment seemed to be given by M. Boettger in good faith as of his own invention, and was apparently received as such by all present, including some names of the highest distinction in science. Neither M. Muller, who has published a work on the progress of electricity, nor M. Buff, who regularly compiles a record of the progress made in physics during each year, nor M. Poggendorff, whose celebrated annals are especially open to physical researches, reminded the speaker that this experiment had been previously published by a German physicist. It was evidently because they themselves did not remember it.

We see frequent examples of this, arising, no doubt, from the multitude of new observations which every day gives birth to. If we dwell

upon the circumstance here, it is because we find in it an answer to one of the many prejudices which the German savant entertains in regard to the French. The latter is currently reproached with publishing in his own name facts discovered and described beyond the Rhine, when the truth is, that the French savant is scarcely ever able to read German, and, if he could, would be quite incapable of keeping pace with the thousand assertions, more or less substantiated, which swarm in Teutonic journals, besides the danger of encountering some other savant better informed with regard to a priority of title. What makes the instance on which we are remarking more singular is, that the experiment of the *jet d'eau* was consigned to the press, not fifty years ago and in some forgotten compilation, but last year, and in the *Annalen der Physik* of M. Poggendorff. It was there that, in seeking for something else, we found it, the morning referred to, but described in still greater detail by M. A. Fuchs, professor in the Lyceum of Presbourg.

The priority of M. Fuchs is doubtless not yet known to our neighbors beyond the Rhine; but when they have learned it, this will not remove the prejudice we have adverted to, nor any other, any more than the French will abandon their opposite propensity to admire all which comes from Germany, and to concede a vast erudition and profound knowledge to every one who calls himself a German professor.

Before leaving the subject of this interesting experiment, we must add that, according to M. Fuchs, the sensibility of the thread of water is such, that when the head of the observer is brought very close to the jet, the latter is deflected if the operator does no more than pass a hand through his hair.

We return to our session, having still to listen to lectures of a high order. Among them, M. Plucker, the eminent professor of the University of Bonn, set forth with great distinctness his remarkable researches respecting the electric spectrum produced by currents of induction, whether in a vacuum or in different mediums, embracing—

- First. A simple gaseous body.
- Second. A mixture of several gases.
- Third. A compound gas.

M. Plucker is convinced that a perfect vacuum is incapable of conducting electricity.

The simple gases which he examined were hydrogen and azote; in exposing a mixture of these two gases to the current generated by an apparatus of Ruhmkorff, a peculiar spectrum is obtained which may be also realized by superposing purely and simply a spectrum produced by hydrogen on another spectrum produced by azote. In effect, the same spectrum results, when a current of induction is made to pass into an atmosphere of ammoniacal gas. Thence we may infer that the ammoniacal gas is decomposed by the current of induction. M. Plucker arrives at analogous conclusions on the subject of carbonic acid, of which the spectrum is identical with that produced by a mixture of oxygen and of the oxyd of carbon, as well as with the image obtained by superposing the spectrums of these two gases.

In addition, the same savant gave an account of the remarkable

effects produced by a magnet on the electric light developed at the negative pole in a gaseous medium. Under the influence of the magnetic fluid, the luminous pencil of the negative pole unites its rays and is contracted into a luminous curve.

It will be understood that we can here scarcely reproduce more than the substance of each lecture; such must be the case, therefore, with the interesting experiments of M. Woehler, with silicated hydrogen, a gaseous compound discovered by himself, and which possesses the curious property of being spontaneously inflammable, like phosphorated hydrogen. The mode of preparing this silicated hydrogen does not differ from the general process followed in the preparation of the greater part of hydrogenated compounds, and yet no one had bethought himself of taking the siliciuret of a metal pertaining to one of the three first sections, and decomposing it by water and an acid. It was not thought of because the preconceived opinion had acquired prevalence, that silicium does not form a gaseous compound with hydrogen; something like fortuity was needed to place the philosopher of Göttingen on the track, and his genius for investigation has done the rest.

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## V.

Coloring matter of bile—Fermentations and putrefactions—A function of arable land—  
Digestion in the vegetable kingdom.

The last session of the section of chemistry was held on the 19th of September. As several remarkable facts were communicated, we shall proceed to sum them up in as few words as possible.

M. Wicke announced that the coloring matter of the shells of eggs offers the strongest analogy to the coloring matter of the bile. By his account, the egg, as yet colorless in the oviduct, acquires its coloration in the cloaca.

M. Schroeder, director of the School of Commerce at Manheim, reported some new observations relative to his ingenious discovery made some years ago, on the subject of fermentation and putrefaction; that these processes do not take place when, instead of leaving the fermentable matter in contact with the common air, we deposit this matter in air which has been previously made to pass through cotton. (See *Journal de Chimie et de Pharmacie*, T. XXV, p. 314.) Meats, bouillon, and all sorts of alimentary substances, have been preserved an indefinite time in this filtered air; the precaution being observed, however, that substances thus treated be first boiled with water.

On the present occasion, M. Schroeder announced that what he had established with regard to fermentation and putrefaction, might be extended also to crystallization. It was already known that a super-saturated solution of sulphate of soda remains liquid in a vacuum, but takes on the crystallizing process upon the admission of atmospheric air. The savant of Manheim showed that crystallization does not take place if the admitted air has been previously passed through a tube fitted with carded cotton.



In his memoir of 1854, M. Schroeder, had explained the preservative action exerted by filtering through cotton by supposing that this process eliminates from the air the spores of infusoria, or the cryptogamic germs originally suspended therein, and which being deposited on the fermentable or putrefiable matter, are developed at the expense of that matter, and give rise to the different products which result from the phenomena of fermentation and putrefaction.

If the experiment with the sulphate of soda seems to establish a relation between crystallization and that other species of molecular movement called fermentation, it tends to prove, also, that these phenomena may take place without the concurrence of the spores of infusoria or of cryptogams suspended in air not filtered. The question, apparently disposed of by the former series of M. Schroeder's investigations, is placed on a new footing, and no longer menaces either the mechanical theory of M. Liebig, nor that which results from the last researches of M. Pasteur on the manner of producing and propagating fermentation.

We cannot leave the subject of chemistry without speaking of a discourse by M. Liebig in the Section of botany, on the nutrition of plants, and the function in regard thereto, of arable land. Till the present time it has been considered that in order for mineral substances to penetrate within a plant, it was necessary that they should be in a state of solution. The water of rain, pure or combined with carbonic acid, would thus be the dissolvent, and the liquid would be absorbed by the roots.

Establishing himself on the facts ascertained by M. Way in relation to the disinfecting action exerted by arable land upon the water of purin, M. Liebig shows that this absorbent action is exercised, in general, upon the saline substances susceptible of serving for aliment to vegetables, and that the absorption is so much the more energetic as the mineral principle is more nutritious for the plant; arable land, for instance, taking up potash more rapidly than soda, conformably with the fact observed by MM. Molaguti and Durocher, that vegetables have much more tendency to absorb the former than the latter, and that certain maritime plants (the *eryngium maritimum*, among others) contain nearly three times more of potash than of soda.

But if the potash, the ammonia, and even the soda, are fixed by arable land, the acids with which they are combined are not absorbed, except in so far as they are susceptible of being useful to the vegetable.

Water the ground with a solution of chloruret of potash or sulphate of ammonia, and then examine the liquid which passes off by way of filtration—that is to say, the water of drainage—the potash and ammonia will have disappeared; the acids, on the other hand, will be found almost entirely present. Irrigate with water containing phosphate of lime dissolved by means of carbonic acid, you will find in the drainage water, the lime which existed in the water used; but you will not find phosphoric acid; that acid will have disappeared, having been fixed in some manner by the arable land.

It is not, then, in the saline solutions that the roots of plants take up the principles which they require; nor is it within the structure of

the vegetable that the saline material is decomposed. The metamorphosis takes place in the soil after the solution has penetrated it, and, strange to say, it takes place precisely in the way most propitious to the development of the plant.

Saline substances, therefore, are not absorbed indifferently by the roots of vegetables; before these can be reached by them, such substances have undergone a sort of preparation which qualifies them for the part they are destined to fulfill in the act of nutrition.

If we could allow ourselves to interpose an opinion on a question handled by such a master as M. Liebig, we would say that this function of arable land might be assimilated to the act of *digestion*.\* What, in natural history, distinguishes vegetables from animals is the absence of a digestive tube, and yet the former feed and grow as well as the latter. The interesting discovery just adverted to, justifies the admission that there may be digestion without a digestive tube. If nutrition, in a word, implies digestion, we may say that in plants this digestion is *external*; while, in animals, it is *internal*.

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## VI. SECTION OF PHYSICS.

Magnetic Currents Developed by Torsion—Electro-statics—Binocular Vision—Apparatus of Ruhmkorff—Photo-chromatic Illumination—Mechanical Equivalent of Heat—Molecular Movement in Gaseous Bodies.

To the researches of a physical nature, which were communicated in the mixed session of the 19th September, we ought to add an account of some other labors, not less important, which were explained by their authors in the special sessions. The first to address the meeting was Professor Wiedemann, of Basle, who gave a summary of his labors on magnetism in its relations with torsion; a noble subject, whose starting point is to be sought in an observation made some twenty years since by Choron,\* and which has been inaugurated by the ingenious researches of M. Wertheim. Prof. Wiedemann has shown that a twisted wire of iron undergoes a detorsion when it is subjected to magnetization, and he is of opinion that the laws which govern the torsion are applicable to the magnetization of bars of steel to such an extent that, in the enunciation of those laws, we might interchange the words to *twist* and to *magnetize*. He conceives that an analogous relation presents itself when we subject magnets to torsion, or when, inversely, we magnetize twisted threads of iron.

After M. Wiedemann, M. de Feilitzsch, Professor of Physics in the University of Greifswalde, entered upon some considerations on the law of currents in its relations with the law of electro-statics. Next,

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\*“On the change of pole produced by torsion in an iron wire properly arranged,” by M. Choron; *Comptes rendus des Seances des l'Academie des Sciences*. XX., p. 1456.

M. Dové, the president of the day, gave some account of his researches on binocular vision, and on the means of combining colors obtained by absorption with colors produced by interference.

In the second session, over which M. Magnus presided, we again encounter M. Boettger, who realizes all sorts of prodigies with the apparatus of Ruhmkorff. He first indicates a very simple means of obtaining a strong electric tension at the extremities of the coil which receives the induction, and, to that end, it suffices to place one of the extremities of this apparatus in communication with the floor; he obtains curious effects by causing the spark of the apparatus to pass through tubes containing ioduret of mercury; at one of the poles the light of the spark is violet, at the other it is red.

M. Boettger exhibited another experiment which could not fail to be attractive to those amateurs who seek amusement in chemistry. In a receiver, like that which is used in the experiment of the *jet d'eau* employed as an electroscope, there is introduced an alcoholic solution of boracic acid and nitrate of strontium; the air is then compressed upon it. By opening the cock with proper precaution a slight thread of liquid is ejected, which, if the interior pressure is sufficiently strong, will rise as high as the ceiling. After having wet this over, if we now apply a lighted match to the jet, the flame is immediately communicated to the ceiling by means of the intermediate thread of alcoholic liquor, and produces a play of colors the most brilliant and diversified.

From a lecture by M. Boettger to one by M. Clausius is something of a stride, especially to those who are likely to be frightened at algebra. M. Clausius is one of the pioneers who have done most for the theory of heat and most contributed to our knowledge of the relations of this force and the mechanical force capable of producing or consuming it. Thanks to his labors and to those of MM. Clapeyron, Mayer of Heilbronn, Hirn of Colmar,\* Holtzmann of Stuttgart, &c., the theorem of S. Carnot, so long inscrutable, has become intelligible to all the world.

We shall not dwell on the purely theoretical subject discussed in this lecture by M. Clausius; suffice it to say that we here trench upon a question as yet but little understood, namely: that of the molecular movement in gaseous bodies.

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## VII.

Magnetic Adhesion—Trifurcated Electro-magnets—Circular Electro-magnets—Magnetic Gearing—Electro-chemical Chronoscopes—Harmony and Disharmony.—New Photometer.

The fifth session of the section of physics, over which M. Jolly, professor in the University of Munich, presided, was opened by a lec-

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\* See *Recherches sur l'équivalent Mécanique de la Chaleur*, by G. A. Hirn, 1858. The author improperly omits the names of Jule and Thompson in this list.

ture in the German language, by the author of the present article, on the electro-magnets invented by himself and on his researches on magnetic adhesion.\* Previous to his labors on this subject, there were but three kinds of electro-magnets known:

1. The *rectilinear*; a straight bar of iron, placed in a coil in communication with the pile.

2. The *horse-shoe*, or *bifurcated electro-magnet*; formed from the above by bending it into the shape which the name indicates.

3. The tubular electro-magnet of Romershausen.

M. Nicklés has contrived—

The *trifurcated electro-magnet*, or that with three poles, having, however, but a single coil, yet exerting considerable attractive force.

The *circular electro-magnet*, capable of transmitting a movement of great velocity, since the wheels of transmission which he proposes are not toothed; their periphery being perfectly polished, they derive their adhesive power from the magnetism developed at their circumference.

Finally, he has introduced the *para-circular electro-magnet*, applicable in the same circumstances, but possessing properties which differ from those of the preceding ones.

The time which the order of the day left at the disposal of the author was too limited to enable him to give many details respecting these instruments, which were in operation, moreover, under the eyes of the auditory. The professors of physics regarded them with some interest, not only as furnishing a new chapter in the history of electro-magnets, but as having a bearing, besides, on certain special applications, with a view to which they were constructed, particularly the transmission of movement: thus, in regard to railroads as a means of increasing the adhesion of locomotives, the author had already made a first attempt at their application to an entire train on the route of the city of Lyons, and on a gradient of nearly one centimeter per meter.† The effect realized was about nine per cent.

His Majesty the Emperor, who, on this first trial, had caused a report to be made to him by a commission of physicists and engineers, has quite recently ordered a renewal of the experiment to be made by the Director of the Bureau of Arts and Trades.

Electricity constituted the occupation of a part of this session. To the lecture just referred to succeeded another on electric chronoscopes, by M. Hessler, professor of physics at Vienna. The speaker passed in review different electro-magnetic chronoscopes, pointed out defects in all of them, and proposed to remedy these by substituting electro-chemical chronoscopes, by means of a current acting on paper impregnated with a solution of ioduret of potassium. This apparatus possesses the great advantage of being able to register the observations automatically.

After M. Belli, professor in the University of Pavia, had explained the properties of an apparatus capable, as he thinks, of indicating the difference between the two electricities; and M. Helmholtz had given

\* *Bulletin de la Société d'encouragement*, May and June, 1853.

† *Moniteur Universel*, 9th May, 1858.

a lecture, which it would be difficult here to reproduce, on the *physical causes of harmony and disharmony*, audience was accorded to the modest and illustrious Schwerd, whose valuable labors in optics are the fruit of the few hours left him by his professional engagements as a private teacher of literature in his native city of Spire. The subject of his present lecture was a photometer constructed by himself, with which he has been enabled to make a series of observations on the fixed and the variable stars. He did not exhibit his apparatus, and the explanations given of it are not of a nature to be understood without drawings; but according to the testimony of physicists who have seen it, and the judgment of the learned astronomer, Argelander, this photometer is calculated to render important service in observatories.

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### VIII.

Calorific Intensity of the Solar Spectrum—Calorific Spectrum—Chemical Spectrum—Luminous Spectrum—Index of Refraction of Calorific Rays—Universal Scientific Congress.

The sitting of the section was closed by M. Muller, professor of physics in the University of Fribourg-en-Brisgau. M. Muller is known to physicists by a series of admirable labors, and especially by his researches on the magnetic maximum of magnetized bars; he is known to studious youth by a treatise on physics, which he reëdits every two years, which at first was only the translation of a French work, but, though still retaining the title of that work, has not the less become an original treatise, entirely independent of that of M. Pouillet. I might appeal for the truth of this to those French professors who read German, and who have—all of them—in their libraries, one or other of the numerous editions of Muller.

In the lecture of to-day, M. Muller submitted his researches on the calorific intensity of the solar spectrum. By means of the heliostat of M. Silbermann the elder, he directs the solar rays through prisms of different kinds, and determines the calorific intensities by means of the apparatus of Melloni. We know, through this savant, that rock salt is the only diathermanous substance which allows the heat to pass entirely, while other bodies always absorb more or less of it. We know, also, that in placing a thermometer in the different tints of the solar spectrum the temperatures indicated are different; they augment in proportion as they advance towards the red, and diminish towards the other extremity. The thermoscopic apparatus detects nothing in this respect beyond the violet and outside of the visible spectrum; it is, on the contrary, sensibly impressed at the opposite extremity, affording an evident proof that the calorific spectrum is not superposed purely and simply on the luminous spectrum.

As much may be said of the chemical spectrum, which occupies, however, the other extremity of the luminous spectrum.

Now, in operating simultaneously with a prism of rock salt, and another of glass, M. Muller has ascertained that the calorific intensity of the curve obtained with these two prisms, is sensibly the same as long as the experiment is confined within the limits of the visible spectrum; but, on the contrary, the intensities differ when we pass beyond those limits.

M. Muller has determined the index of refraction and the length of the wave of the extreme calorific rays; he has studied the manner in which the heat is distributed in the different spectrums, and has summed up his researches in a series of curves which we cannot here reproduce. His labors will, without fail, be published in one of the special journals of Germany.

We have thus recapitulated the principal communications in physics and chemistry which were submitted during the six days the conferences lasted. However imperfect our report, the reader will have perceived that the meeting was an imposing one, both in its relations to science and to the interest excited in the society of Baden; in fact, if the scientific discussions were not more numerous, this was owing in great measure to that hospitable and enthusiastic spirit which led, not Carlsruhe alone, as might have been the case with any other capital, but every petty city of the Grand Duchy, to make a point of receiving and fêting the distinguished body of *Naturforscher*, whom the occasion had brought together. As regarded one of its principal aims, the introduction of men of science to a personal and friendly acquaintance with one another, the Congress must be considered as having been eminently successful. Old attachments were refreshed and new relationships contracted; misunderstandings were cleared up, and scientific differences dispelled by a frank and courteous discussion. Outwardly, everything conspired to promote this spirit of fraternization: the streets festooned with flags, the mottoes everywhere inscribed in letters of gold, constantly reminded us that we are the artificers of a common work and all engaged in the pursuit of the same object.

To perpetuate the remembrance of this Congress, the Grand Duke caused a commemorative medal to be struck and presented to each of the enrolled members. Decorations were, besides, conferred on some of the admitted leaders of science. Of these, two were designated for foreigners, one of which, by an incontestible right, fell to the share of M. Despretz, the preëminent representative on this occasion of French science; the other was allotted to M. Stás, the learned chemist of Brussels.

The whole duration of the Congress was eight days. At the general session which closed it, a letter from M. de Caumont was read, inviting the savants of Germany to take part in the scientific reunions of France, the next of which is to assemble at Limoges. As these meetings are always held from the 1st to the 10th of September, the writer of the letter argued that between the closing of the French and opening of the German Congress there would be time enough for members to repair from one to the other.

This may well be doubted, since five days seems a rather uncertain apportionment of time for the transit from Limoges, for instance, to

Königsberg, on the northern confines of Germany. Nor should it be forgotten that England also holds a scientific congress, and, like the others, in the month of September. Each of these assemblages will place in requisition a certain number of men of science and prevent them from attending elsewhere, notwithstanding the present celerity of travel. To escape from this difficulty, it remains to take a step which will be effected sooner or later, that is, to substitute for all these partial reunions a scientific congress for all Europe, to be replaced hereafter, in turn, by a *Universal Scientific Congress*, which shall sit, in order of succession, in the principal cities of the old and new continents.

# MEMOIR OF HAÜY.

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READ BEFORE THE FRENCH ACADEMY OF SCIENCES, BY BARON CUVIER, PÉRPETUAL SECRETARY.

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TRANSLATED FOR THE SMITHSONIAN INSTITUTION BY C. A. ALEXANDER.

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In the history of science, epochs occur when the human mind seems to take a surprising stride. When years have been spent in the patient accumulation of facts and observations, and the received theories no longer suffice to harmonize them, ideas respecting natural phenomena become in some measure incoherent and contradictory. System is no longer possible, and the need is universally felt of some new bond of connection. Should a genius appear at such a juncture, capable of rising to a point of view from which some of the required relations may be embraced, fresh courage is diffused among cotemporary inquirers, each throws himself with ardor into the new paths which have been opened, and discoveries succeed one another with increasing rapidity. Those who have successfully associated their names with the movement assume, in the eyes of their followers of a later generation, the proportions of some superior race; and, as they pass successively from the stage of life, are deplored as heroes whom the world must despair of ever seeing equaled.

Such an epoch the close of the eighteenth century unquestionably was, as regards the natural sciences.

The laws of a geometry, as concise as comprehensive, extended over the entire heavens; the boundaries of the universe enlarged and its spaces peopled with unknown stars; the course of celestial bodies determined more rigorously than ever, both in time and space; the earth weighed as in a balance; man soaring to the clouds or traversing the seas without the aid of winds; the intricate mysteries of chemistry referred to certain clear and simple facts; the list of natural existencies increased ten-fold in every species, and their relations irrevocably fixed by a survey as well of their internal as external structure; the history of the earth, even in ages the most remote, explored by means of its own monuments, and shown to be not less wonderful in fact than it might have appeared to the wildest fancy: such is the grand and unparalleled spectacle which it has been our privilege to contemplate, but which renders only more bitter the disappearance of those great men to whom we owe it. Few are the years which have seen the tomb close upon a Lavoisier, a Priestley, a Cavendish, a Camper,



a De Saussure, a Lagrange; and who but must be startled at the acceleration in our losses, when a few months only have snatched from us Herschel and Delambre, Haüy and Buthollet, leaving us scarce power to render, within the prescribed time, the homage due to them by the societies of which they were the ornament.

We might be the more tempted to believe that Haüy felt this irresistible impulse of his epoch, from his having been determined, almost without being aware of it, to a career for which, during the first forty years of his life, he had never thought of preparing himself. In the midst of obscure occupations an idea dawns upon him; a single idea, but one equally luminous and prolific. From that moment he never desists from following it; he devotes to it his time, his faculties, his undivided attention, until finally a brilliant success is the crown and recompense of his efforts. No example could better show the grand, I had almost said miraculous, results which spring from the profound and exhaustive study of a subject upon which the mind is concentrated, nor prove more clearly the truth of the maxim, that, at least in the exact sciences, it is the patience of a sound intellect, when that patience is indomitable, which truly constitutes what we call genius.

René-Just Haüy, an honorary canon of Notre Dame, a member of this academy, and of most of those of Europe and America, was born the 28th of February, 1743, at Saint-Just, a small market town in the department of the Oise. A younger brother of his has made himself known by an original method for instructing those born blind; while the father of both was a poor weaver, who could probably have given them no other profession than his own, had not the liberality of others come to his aid.

The first change for the better in the fortunes of the two brothers may be ascribed to the pious turn of the elder, manifested in his earliest years and governing his whole life. Even in infancy he evinced a singular pleasure in religious ceremonies, especially in the choirs of the church; a taste for music, the natural concomitant of tender sentiments, having thus early allied itself in him with the feelings of devotion. A Premonstratensian prior of his native town, who had observed the assiduity of his attendance at Divine service, engaged him one day in conversation, and, being struck with the vivacity of his intelligence, procured him the instruction of some of his monks. The child's progress, promptly responding to the care of these masters, interested them more and more, and led them to suggest to his mother that by removing him to Paris she might shortly procure through their recommendation such resources as would enable him to complete his studies.

This excellent woman had scarcely sufficient means for a few months subsistence in the capital; but she preferred encountering any extremity to proving false to the future which might await her son. It was long, however, before her tenderness met with any but the most slender encouragement. The place of chorister in a church of the quarter Saint Antoine was the only means of livelihood available to a youth whose name was destined to be one day known to all Europe. This post, he used afterwards pleasantly to say, was at least so far propitious that it prevented him from burying his musical talents; at

any rate, by fostering his original taste, it enabled him to become a respectable performer on the violin and harpsichord, two instruments with which he solaced himself during life. Finally, the interest of his patrons of Saint-Just obtained for him a scholarship in the college of Navarre, where it first became possible for him to enter regularly on a course of classic instruction.

Here his conduct and application gained him favor, as they had done at Saint-Just. The heads of the college engaged his services as teacher as soon as he had ceased to be a pupil, and even advanced him to the mastership of the fourth class before he had quite reached the age of twenty-one years. Transferred some years later to the College of the Cardinal Lemoine, in a similar but higher capacity, he might seem to have limited his ambition to such modest, however useful, functions. It is true that, at Navarre, he had imbibed from M. Brisson, of that Academy, some taste for experimental physics, and at moments of leisure had even experimented with electricity; but this was rather by way of recreation than study; while natural history, properly so called, does not appear to have, in the least, occupied his attention.

If, at last, he found the path which was to conduct him in the end to so high a renown, it was still owing to the gentler dispositions of his nature; so that the fame and fortune of Haüy may be said, with literal exactness, to have been, at every step, the recompense of his virtues.

Among the regents of the College Lemoine there was at this time a learned individual who had devoted himself to the instruction of youth from a principle of piety. Capable of enlightening persons of the maturest age, Lhomond had chosen to restrict himself to compositions for the use of the young; but had contrived to impart to them so admirable a tone of simplicity and clearness that their success has been seldom equaled by works of greater pretension. Between him and Haüy there existed so striking a conformity of character and sentiments that the latter had chosen him for his friend and confessor; interested himself, with the devotion of a son, in his affairs; tended him in sickness, and was the companion of his walks. Lhomond cultivated botany, and Haüy, who had scarcely heard of it, felt a chagrin at not being able to add the common study of this as a new charm to their intercourse. In one of his vacations he discovered that a monk of Saint-Just amused himself with the study of plants. The idea at once struck him that he might give an agreeable surprise to his friend, and, with this sole view, he requested the monk to convey to him some notions of the science and some acquaintance with different species. His heart came to the aid of his memory; he comprehended and retained all that was shown him, and the surprise of Lhomond was unbounded, when, at their next herborization, Haüy named to him, in the language of Linnæus, most of the plants they met with, and showed that he had studied and analyzed their structure.

From that time everything was common between them, even their amusements; but from that time, also, Haüy became thoroughly a naturalist, and an indefatigable one. It might be said that his mind had been wakened of a sudden to this new kind of enjoyment. He

prepared a herbarium with unusual care and neatness, and even invented processes by which the color of his flowers has been preserved to the present day.\* Here he took his first lesson in the right use and aims of method, and by frequenting the "Jardin du Roi," which was near his college, he extended his ideas and exercised himself more and more in the work of classification and comparison.

Happening one day to join the crowd which at that time attended the lessons on mineralogy given by Daubenton in the "Jardin du Roi," he unexpectedly found himself in the presence of a new object of study, more congenial to his first taste for physics than even that of plants. Numerous, however, as was the attendance on Daubenton's lessons, it was mainly of such auditors as left botany and mineralogy where they found them. Having come earlier to the study, they might know more of both than Haüy; but custom itself, in familiarizing them with the difficulties of those sciences, had caused them to disappear. To Haüy, who came later, these difficulties presented themselves after a different manner. The contrarieties and gaps in the series of ideas strongly arrested the attention of a vigorous thinker, who, in the height of his powers, approached for the first time a new object of study. If the constancy observable in the complicated forms of flowers and fruits, and all the parts of organized bodies, affected him with admiration and wonder, how is it, he might ask, that the forms of minerals, so much more simple and even geometric, are not subjected to similar laws? for, at that time, even the partial and imperfect relationship proposed by Romé Delisle, in the second edition of his Crystallography, was unknown. How is it, might Haüy say, that the same stone, the same salt, show themselves in cubes, in prisms, in needles, without the change of an atom in their composition; while the rose has always the same petals, the acorn the same curvature, the cedar the same height and the same development?

While absorbed in these ideas, it chanced that in examining some minerals at the house of a friend, he was so fortunately awkward as to let fall a beautiful group of calcareous spar crystallized in prisms. One of these prisms broke in such a way as to exhibit at the point of fracture planes not less smooth than the original surface, but presenting the appearance of a new crystal, wholly different in form from the prism. Haüy observes this fact, and attentively examines the planes and angles of the fragment. To his great surprise, he finds that they are the same with those of Iceland spar crystallized in rhomboids. He returns to his own cabinet, selects a specimen crystallized in the form of a six-sided pyramid, such as is usually called *dog tooth spar*, and breaking it, sees the same rhomboid of the Iceland spar emerge; the splinters which fall are themselves smaller rhomboids. He tries a third spar, called from its form *lenticular*, and still it is the rhomboid which discloses itself in the center, and smaller rhomboids detach themselves in the fragments.

He might well exclaim, all is clear; the particles of calcareous spar have but one and the same form: it is only in grouping themselves

\* See his "manner of forming herbariums," in the Memoirs of the Academy for 1785, page 210.

differently that they compose the crystals whose external shape deludes us by its variety. Setting out with this idea, he could readily imagine that those particles, in accumulating and disposing themselves in layers, might form pyramids and polyhedrons of a new configuration; enveloping the primitive crystal as with another whose exterior faces might differ much, both as to number and inclination, from those of the first, according as the successive layers had diminished on one side or another, and in such or such proportions.

If this, then, was the true principle of the crystallization in question, it could not but prevail in the crystals of other substances; each of which ought, in like manner, to have its constituent particles the same, a nucleus alike in each species, and superposed or accessory layers producing all the varieties. Haüy, who hesitates not to submit to the hammer his own crystals, as well as those he could obtain from his friends, finds everywhere a structure based upon the same laws. In the garnet it is tetrahedral; in fluor spar, octahedral; pyrites presents a cube; while gypsum and heavy spar offer straight four-sided prisms, whose bases, however, have different angles. Invariably the crystals break with faces parallel to those of the nucleus, the exterior form being but the result of the more or less rapid decrease of the superposed laminae, a decrease which takes place sometimes at the angles and sometimes on the sides. Thus, the new surfaces presented are in reality a succession of minute points produced by the retreating laminae, though they appear smooth to the eye from their extreme tenuity. No crystal which Haüy examines offers any exception to his law, so that he exclaims, and this time with more assurance, *all is clear*.

But, that this assurance should be complete, a third condition is to be fulfilled. The nucleus or constituent molecule having in each case a fixed form, geometrically determinable as to its angles and the correspondence of its lines, every law of decrement must cause the secondary surfaces to be in like manner determinable; indeed, the nucleus or molecule being given, it should be possible to calculate beforehand what angles and lines the decrease in each instance would prescribe to all the secondary surfaces. In a word, that the theory should be certain, it was necessary here, as in astronomy and every part of physics, that it should not only explain with precision all known facts, but that it should provide with equal precision for those which had not yet come to light.

This Haüy perceived, but fifteen years passed chiefly in teaching Latin had nearly effaced the small portion of geometry taught him at college. Without being deterred by this, he tranquilly set himself to regain it; and as he had so quickly learned botany to please his friend, he could not be long in acquiring enough geometry to complete his discovery. Nor was his recompense delayed beyond the first trial of this new auxiliary. The hexahedral prism which he had broken by accident was found, upon calculation, to yield a value closely approximate to that of the angles of the molecule of the spar; other calculations gave him that of the retreating surfaces, the application of the instrument to the measurement of the angles giving direct confirmation to the provisions of theory. In other crystals the secondary were found to be as easily deducible from the primitive planes, while in

nearly all cases the decrements, by which the secondary planes are produced, were found to exhibit the simple proportions which nature seems to have established in all the relations of number. Without further hesitation might Haüy now, for the third time, exclaim—*all is clear*; and at this stage only of his discoveries did he feel confidence enough to speak of them to Daubenton, the master whose lessons he had hitherto followed in modest silence. We may judge in what manner they were received from the fact that Laplace, to whom they were communicated by Daubenton, and who at once foresaw their consequences, lost no time in pressing the author to come forward and present them to the Academy.

This it was not so easy to induce him to do. To the worthy professor of the College Lemoine the Academy was a *terra incognita* at which his diffidence took alarm. Its usages were so little known to him that he at first presented himself in the long robe which ancient canons of the church are said to prescribe, but which no ecclesiastic has for a long time worn in society except on strictly professional occasions. Certain friends were apprehensive that, at a period of so much levity, this robe might occasion a loss of votes; but to induce so scrupulous a casuist to quit it, nothing less was necessary than an appeal to the advice of a doctor of the Sorbonne. "The ancient canons of the church," said this wise referee, "are no doubt highly respectable, but what is of consequence at this moment is, that you should belong to the Academy." We are at liberty, however, to believe that the precaution was superfluous, and that he would have been received, no matter in what vestments he had presented himself. So emulous, indeed, was the Academy of such an acquisition that, without waiting for the vacancy of a place in physics or mineralogy, one in botany, which circumstances had rendered disposable, was conferred on him with nearly entire unanimity, and even in preference to learned botanists.

A still more flattering proof of the regard of his new colleagues was, that, by several of the most distinguished among them, he was pressed to give a course of lectures and demonstrations in elucidation of his theory. Lagrange, Lavoisier, Laplace, Fourcroy, Berthollet, and Morveau might have been seen repairing to the College Lemoine to attend the lessons of the modest professor, whom we may well suppose confounded at finding himself become a master where he would have scarcely presumed to call himself a disciple. But in a doctrine so new, yet already nearly complete, the most skillful could be but learners. Never, perhaps, had a theory of the same extent been presented in the same state of clearness and development from its very origin as that of Haüy, who had invented even the required methods of calculation, and had represented in advance, by formulas of his own, all the possible combinations of crystallography.

From no instance more clearly than from this may we learn to distinguish between the solid labors of genius, on which imperishable structures are reared, and the ideas, more or less happy, which present themselves for a moment to certain minds, but, for want of being elaborated, produce no durable results.

Six or seven years before Haüy, Gahn, a young Swedish chemist,

since professor at Abo, had likewise remarked that in breaking a crystal of pyramidal spar its nucleus was a rhomboid similar to Iceland spar, and he had communicated this observation to his master, the celebrated Bergman, who would have been thought capable of following it into all its consequences. But in place of extending it to different crystals, and thus ascertaining by experiment within what limits the fact might be generalized, Bergman launched into hypothesis and lost his way from the outset. From the observed rhomboid of spar he pretended to deduce not only the other crystals of spar, but those of the garnet and hyacinth, which have no conformity of structure. Thus, a savant of the first order, a proficient in physics and geometry, bewildered himself in the path to a great discovery, and left it to be made by a man who was scarcely beginning to occupy himself with science, but who knew how to pursue truth as Nature wills it to be pursued; in proceeding step by step, observing without remission, and not suffering oneself to be carried away or turned aside by the imagination.

The mineralogists, however, who had been unable to find the right way, now, from the same cause, proved themselves as little capable of perceiving how far that of Bergman diverged from it, and they charged Haüy with borrowing Bergman's ideas—Haüy, who scarcely knew the name of Bergman, and had certainly never seen his memoir. They added, as is always done on similar occasions, that not only was the discovery not Haüy's, but that it was false.

Romé Delisle, a mineralogist, not otherwise without merit, but who had long been occupied with crystals without once suspecting the principle of their structure, had the weakness to deny it when discovered by another. He amused himself with calling Haüy a *crystalloclast*, as the breakers of images were called *iconoclasts* under the Lower Empire. But happily we know no heretics in science except those who do not choose to follow the progress of their age; and it is Romé Delisle himself, and others actuated by similar jealousies, who must be referred to the class of the perverse and contumacious.

The only response of Haüy to his detractors consisted in new researches, and a still more fruitful application of them. As yet, he had but given the solution of a curious problem in physics; his further observations were destined to furnish indications of the highest importance to mineralogy.

In his numerous experiments upon the spars, he had remarked that the stone called *pearl spar*, which till then had been regarded as a variety of the heavy spar, or sulphate of barytes, has the same nucleus with the calcareous spars; and his analysis proved that, like them, it consists only of carbonated lime.

If minerals, he reasoned, well ascertained as to their species and composition, have each a determinate nucleus and constituent molecule, the same must be the case with all the minerals distinguished by nature whose composition is not yet known. For the distinction of substances, then, this nucleus or molecule may supply the place of their composition; and from the first application of this idea he was enabled to carry light into a part of the science which all the labors of his predecessors had failed to make clear.

At this epoch, the most expert mineralogists, Linnæus, Wallerius,

Romé Delisle, even Saussure himself, confounded under the name of *schorl* a multitude of stones which had nothing in common but a certain fusibility joined to a form more or less prismatic; and under that of *zeolite* a multitude of others, whose sole distinctive character was to change, with acids, into a sort of jelly. The *schorls* especially formed a most heterogeneous assortment; every mineral of which there existed no clear idea being referred to it; which led the illustrious Lagrange to say, jestingly, that *schorl* was the *nectary* of the mineralogists, because the botanists were similarly accustomed to call by the name of *nectary* every part of the flower whose nature they were ignorant of.

On subjecting to mechanical division the stone known as white *schorl*, (*schorl-blanc*,) Haüy was surprised at finding the nucleus and molecule of feld-spar. A test supplied upon this indication, by the chemist Darcet, manifested the identity of the *schorl* in all its physical and chemical characters with the feld-spars.

Thus encouraged, Haüy proceeded to examine other *schorls*. He discovered that the black stone with which so many lavas are strewn, and which had been called *volcanic schorl*, has for its nucleus an oblique prism with rhombic base, and the pretended *violet schorl* of Dauphiné a nucleus whose prism is straight; both, therefore, were to be separated from the family of *schorls*. Still later, he succeeded in distinguishing the *electric schorl* or *tourmaline* from the *black schorl of primitive formation*, the nucleus of the first being a regular hexahedral prism, that of the last simply tetrahedral. Thus, one after another, under his continued researches, the pretended *schorls* were divorced from the varieties with which they had been improperly associated, and assigned by fixed characters to their proper groups. The same success attended his method in distinguishing the stones confounded under the name of *zeolites*. Chemistry and physics, prompted by these results of crystallography, were everywhere enabled to find in minerals characters or elements which had not before been detected.

From this time Haüy might be said to have become the lawgiver of mineralogy. By his researches on the *schorls* he had inaugurated a new era in the science; and every subsequent year has witnessed some unexpected discovery, due to the study of the crystalline structure of minerals.

Among the *schorls*, he finally distinguished fourteen species, six among the *zeolites*, four among the *garnets*, five among the *jacinths*. Not only were the chemists guided by these labors to the detection of unsuspected differences in the composition of stones; there were scarcely less frequent occasions when Haüy could predict that the differences which they had assumed could not exist. Thus, Vauquelin, who had before discovered *glucine* in the *beryl*, was led by the indications of crystallography to find it also in the *emerald*.

It was not always that Haüy recognized at first the indications furnished by his own researches; he might sometimes neglect to compare their results. When Klaproth and Vauquelin, for instance, had discovered that the *apatite* and the *chrysolite* of the jewelers were but phosphate of lime, Haüy, on recurring to his papers, found that he had himself long before determined the same structure for both; and

this coincidence in the result of operations conducted separately and without concert was, in his eyes, a decisive triumph for crystallography.

It was imperative on a man who served the sciences after this manner to devote himself exclusively to them. By the counsel of Lhomond himself, when the twenty years' service requisite for a pension of *emeritus* in the University was fulfilled, Haüy lost no time in demanding it. He had, besides, a small benefice, the whole not amounting to more than what was strictly needful; but for him, who knew no pleasure but in work, it would have sufficed if that needful, at least, had been assured to him. Unfortunately, he was to learn, within a very short time, that the effects of human passions are not so easily calculated as those of the forces of nature.

It will be recollected with what imprudence the Constituent Assembly, under the control of factious spirits, allowed itself to combine theological disputes with all the other disputes which then agitated France, thus doubling the asperity of political quarrels by giving them the character of religious persecutions. The new form of government imposed on the Church had divided the clergy, and the men who wished to carry the revolution to extremes took a pleasure in exasperating their dissensions. Such ecclesiastics as resisted innovation were deprived of their places and pensions, and Haüy, whose scrupulous piety consigned him to that class, found himself in a moment as poor as on the day when he aspired to the situation of singing boy.

He would have been content, however, had he been allowed to live by his labors; but the persecutors could not be satisfied with a first vexation. One of the earliest acts of the reckless men who mounted to power on the ruins of the throne, August 10, 1792, was to imprison the priests who had not taken the prescribed oath, and the scientific celebrity of Haüy furnished but a reason the more for including him in the common lot.

Little aware, in his solitude, of what was passing around him, it was with surprise that he one day saw a party of rough men insolently entering his modest retreat. They begin by demanding if he has fire-arms. "None but this," said Haüy, drawing at the same time a spark from his electric machine. For an instant these brutal personages feel themselves disarmed; but the next, they proceeded to seize upon his papers, which contain nothing but algebraic formulas; overturn the collection, his only property; and end with conducting him to the Seminary St. Firmin, contiguous to the College Lemoine, and recently converted into a prison, where all the priests and professors of that part of Paris were confined.

One cell for another made but little difference to Haüy. Tranquilized, moreover, at finding himself in the midst of many of his friends, he felt but little concern, except to send for his cabinet of drawers and endeavor to restore his crystals to order. Happily, outside the prison there were friends of his, better informed as to the course which things were taking.

Geoffroy de Saint Hilaire, Haüy's pupil and subsequently his colleague in this Academy, lodged, then, at the College Lemoine. No sooner did he learn what had happened, than he hastened to implore



the intervention of all the personages who were likely to be of service. Members of the Academy, and functionaries of the "*Jardin du Roi*," did not hesitate to throw themselves at the feet of the ferocious men who were conducting this frightful tragedy. An order of deliverance is obtained and borne by St. Hilaire to the prison. But he arrives a little late in the day. Haüy is so tranquil, so comfortable, that nothing can determine him to leave that evening. The next morning it is almost necessary to withdraw him by force. One shudders to think that the day after was the 2d of September!

It is a singular fact that from that time he was never molested. Nothing certainly could have induced him to lend his countenance to the extravagances of the period; but no one proposed to him to do so. The simplicity and mildness of his manner and character seem to have stood him in stead of all else. Once only was he summoned to appear at the review of his battalion, but they cashiered him on the spot for his awkward appearance. This was nearly all that he knew, or at least saw, of the revolution. The convention, at a time when it was proceeding with the most violence, named him a member of the Commission of Weights and Measures, and Keeper of the Cabinet of Mines. And when Lavoisier was arrested, and Borda and Delambre dismissed, it was Haüy, a recusant priest, discharging every day his ecclesiastical functions, who alone found himself in a position to write in their behalf, and who did so without hesitation and without incurring inconvenience. Considering the time, there is even more cause to wonder at his impunity than his courage.

It was at the Cabinet of Mines, and on the invitation and with the aid of the enlightened administration of that department, that Haüy prepared his principal work, the treatise on mineralogy. Having at his disposal a vast collection, to which minerals were consigned from all quarters, and at the same time the services of the young and ardent scholars of the polytechnic school, (more than one of whom have since become eminent mineralogists,) Haüy promptly retrieved the time consumed in other labors, and in a few years reared that admirable monument of which it may be said that it effected for France what retarded circumstances had accomplished for the author himself; having at once restored that country, after long years of neglect, to the first rank in this division of natural history. This work unites, indeed, two advantages which seldom meet: the first; that it is founded on an original discovery, entirely due to the genius of the author; the second, that this discovery is followed up and applied with unexampled perseverance, even to the most minute mineral varieties. All is grand in the plan; all is precise and rigorous in the details. It is complete; like the doctrine itself of which it contains the exposition.

Of the departments of natural history, mineralogy, whose objects are the least numerous and least complicated, is that, notwithstanding, which yields itself least readily to a rational classification.

The first observers distributed and named the minerals vaguely from their external appearance and use. Only towards the middle of the eighteenth century was the attempt made to submit them to the methods which had rendered such service to zoölogy and botany; though in thus aiming to establish among them genera and species as among

organized beings, it was forgotten that in mineralogy the principle is wanting which has given birth to the idea of species, namely, that of generation; and that even the principle of individuality is scarcely admissible, when our conception of it is founded, as in the organic world, on a unity of action among different organs concurring to the support of a single life.

It is not by the material that the identity of species in plants and animals manifests itself, but by the form, as the name of the species itself indicates. No two men, perhaps, nor oaks, nor roses, have the substances which compose their material in the same proportions; and even those substances are in a state of incessant change: they circulate rather than reside within that abstract space and outline which we call the form of the object. In a few years there will remain, perhaps, not not an atom of what composes our body to-day. It is the form alone which is permanent, and which, transmitted by the mysterious process of generation, will continue to attract to itself, through an endless succession of individuals, molecules as different in their source as transitory in their condition.

On the contrary, in minerals, where there is no apparent movement, where the molecules remain fixed until separated by some external force; where the material, in a word, is permanent, it would seem at the first glance that this, or in other terms the chemical composition, ought to constitute the essence of the thing. But reflection teaches us that if the things themselves are different, this can scarcely happen except through the form of their molecules; that from the peculiar form of these molecules, and their respective mode of grouping, there must necessarily result determinate forms in the mass; and that in mineralogy, if there is anything which can represent the individual, it must be those resulting forms when they exhibit a regular whole; that is to say, a crystal; since at the moment, at least, when this crystal came together, all its constituent molecules must have concurred in a common movement and grouped themselves by the force of some common law. Now, nothing proves that in this common movement particles of a different nature which happened to be within the same sphere of action may not have been involved in it, nor that elements or atoms identical in their nature may not, at the moment of contracting their original union, have grouped themselves into different crystallized molecules. But that which the mind conceives as possible, experience has taught us to be real; whence, it is evident that, in these two cases, chemical analysis would give but an incomplete idea of the mineral, and one not at all in accordance with those of its properties which are most obvious. Such are the views, doubtless, which, without being very distinctly taken into account by Haüy himself, guided his genius, or, if the expression be preferred, his scientific instinct, and led him to assign crystallization the first rank in his determinations of mineralogical species.

All the discoveries and observations since made, even those which have been looked upon as objections to this fundamental rule, may be said rather to be confirmations of it. Thus, for example, what has been just said of the crystallizing force and its power of engaging other molecules with the essential ones, is so true that the former are attracted

sometimes in much the greater quantity; and this to such an extent that a single mineralogical species, iron spar (*le fer spathique*) for instance, which is specifically a calcareous spar or carbonated lime, may contain a fourth, or even third, of its weight of iron, and thus become, for the metallurgist, a real mine, rather than a simple stone; as muriatic spar, which is likewise a calcareous spar, may envelop grains of grit (*grès*) in such measure as to contain little else, without having the angles of its crystals changed by a single second.

It is the same thing in our own laboratories as in that of nature. In causing a mixture of two salts to crystallize, Beudant observed that one of them constrained the other to blend with its crystals in a much larger proportion than that furnished by itself. Which, then, of the two ought to characterize the mineral? The most abundant? By no means; for, with the exception of that abundance, all the characters of the product are given by the other.

Nor is it less certain that the same substance, at the instant of passing into a crystallized form, or of individualizing itself, if the expression may be allowed, takes sometimes a very different form from that in which it usually appears. All the efforts of chemists have failed to discover in *arragonite* any essential matter but the carbonated lime, of which calcareous spar is likewise composed; for the small portion of strontian found in the former can only be regarded as accidental; and yet the crystals of arragonite are octahedral, and those of the spar rhomboidal. And here the art of man equally succeeds in imitating nature, or, indeed, effects at will what nature has rarely done. Recent experiments by Mitscherlich seem to prove that certain salts, in crystallizing, take different elementary forms, according to the circumstances under which they are made to crystallize. But in the small number of cases, where nature herself has produced such differences, are we justified in making but one species of these several crystallizations? As well might we make but one of almost all the warm-blooded animals, for they, too, are as identical in the chemical nature of their elements as the two stones named above. An eagle and a dog have the same fibrine in their muscles; the same gelatine in their membranes; the same phosphate of lime in their bony structure. Like the calcareous spar and the arragonite, they differ only in the form which these materials have taken at the moment of constituting the individual.

Let it be remarked that what is here said imports no neglect of the chemical analysis of minerals, as none certainly was ever countenanced by Haüy himself. Such analysis is quite as essential to a knowledge of them as is that of their form; it is much more important as regards their uses. Haüy maintained only that analysis is generally powerless to determine the species of minerals, because it has no certain means of distinguishing their accidental from their essential substances; because it is not competent, as to certain classes of stones, to affirm that it has detected their elements, and every day brings to light results which had escaped its observation.

Werner, long regarded by Europe as the rival and even adversary of Haüy, differed from him in effect only, in not having carried the research of principles to so high a point. Hardness, fracture, tissue,

the qualities to which Werner attached himself by preference, are in reality but consequences of the form of the molecules, and of their arrangement; and the happy use which this great mineralogist made of them, to recognize and determine so many species of minerals, may enable us to judge with what success he might have resorted to the source, when its simple derivatives were made by him so fertilizing. But of that source we are indebted to Haüy, not only for the knowledge, but for the measure, also, of its force and its abundance. Hence it was practicable for him alone to carry or to reduce to their just value many results which had remained, in a manner, but half truths in the hands of Werner.

There is, at this day, scarcely a known crystallizable mineral whose nucleus and molecules, with the measure of their angles and the proportion of their sides, have not been determined by Haüy, and of which he has not referred to those first elements, all the secondary forms, by discriminating for each the different decrements which produce it, and ascertaining by calculation their angles and faces. In this way he has at length made of mineralogy a science as precise and methodical as astronomy itself.

We may say, then, in a word, that Haüy is to Werner and Romé Delisle what Newton was to Kepler and Copernicus.

But what is more peculiarly his own, is, that Haüy's work is not less remarkable in point of composition and method, than for the original ideas on which it is founded. The purity of the style, the elegance of the demonstrations, the care with which all the facts are collected and discussed, would have made a classic of the most ordinary system of mineralogy. The trace of his earlier studies reappears in the skillful writer and sound geometrician; and even that of his first scientific recreations may be distinguished in the readiness with which the physicist always comes to the support of the crystallographer, supplying him with ingenious processes and convenient instruments, whenever it becomes necessary for him to appreciate the electricity of bodies, their magnetism, and action upon light. There is a rank in science which must be accorded as soon as challenged, and to that rank did Haüy ascend from the day his work was given to the world.

Nevertheless, on the death of Daubenton, it was Dolomieu, and not Haüy, on whom the professorship of mineralogy in the Museum of Natural History was conferred. But, at that moment, arrested in violation of all law, Dolomieu languished in the dungeons of Sicily. The only token that he yet lived, consisted in a few lines, which, from the midst of his chains, he had found the means of writing with a splinter of wood and the smoke of his lamp, and which the ingenious humanity of an Englishman, seconded by gold, had contrived to extract from the hands of the gaoler. These lines spoke as eloquently in his behalf as his works; and among those who solicited the most warmly for him was Haüy, the rival from whom he had most to apprehend.

It might be thought that such marks of consideration, rendered by such men, would have softened the executioners of Dolomieu; but men in authority, urged by the passions of the hour, as seldom inform themselves of the sentiments of their cotemporaries as they foresee the

scorn and indignation of posterity. Dolomieu emerged from his dungeon only through an article in the treaty of peace, and a premature death, the fruit of such treatment, but too soon devolved on Haüy the place which he had so generously renounced. He was nominated the 9th of December, 1802.

From that time new life was infused into the establishment; the collections were quadrupled; an order, constantly conforming itself to the most recent discoveries, reigned throughout. The mineralogical public of Europe pressed forward, as well to observe objects so judiciously arranged as to hear a professor so elegant, clear, and withal so complaisant. His natural kindness showed itself at every instant towards all who desired to learn. He refused himself to no explanations, but received in his privacy, and with equal benignity, persons of the most opposite conditions in life; for the most learned and august, as well as the humblest, might have been seen in the retinue of Haüy's disciples.

From its foundation the University had felt itself honored in placing the name of Haüy on the list of one of its faculties, and, as no lessons were required from him, an adjunct every way worthy had been assigned him in the person of Brougniart, since a member of the Academy, and his successor in the Museum of Natural History. But Haüy had no wish to bear a title without fulfilling its duties. He drew around him the pupils of the normal school, and in varied and familiar conversations initiated them into all his secrets. His college life seemed thus to revive for him, as he entered even into the sports of these young people, whom he never dismissed without an ample collation.

In this manner his days flowed on, occupied completely by his religious duties, by profound researches continually renewed, and by acts of kindness, especially towards the young. Equally tolerant and pious, he suffered no difference of opinion to influence his conduct towards others; equally pious as faithful to his studies, he would have allowed no contemplation, however sublime, to interfere with the observances prescribed by the ritual: placing, for the rest, on the things of this world, only the value which they bear in the eyes of a man penetrated by such sentiments. From the nature of his researches, the gems of all Europe were constantly passing under his eyes, and even gave rise to a special treatise from his pen; but to him they were only so many crystals; a degree, more or less, in some angle of a schorl or spar would beyond doubt have interested him more than the treasures of the two Indies. Indeed, if he can be reproached with too warm an attachment to anything, it was to his ideas on this subject. It was not without impatience, sometimes, that he saw them controverted, and here only, where he had concentrated all his interest, could a motive sufficiently powerful be found to disturb his habitual serenity and kindness. Thus he was prevented from accepting, with due acknowledgment, probably, the observations made by means of the new goniometer of Wollaston, on the angles of the calcareous and iron spar. But who will not excuse a valetudinarian and recluse, who had been attacked from the outset in the most unjust and offensive manner, if he sometimes failed to distinguish from his first ignorant assailants

those who, enlightened by his own discoveries, arrived in the sequel at a different estimate of certain facts of detail, or even principles, which he had too widely generalized? Certain it is, that in those moments, when such a tribute to human weakness was extorted from him, he felt only for what he supposed to be the interests of science, and if angry, it was simply at what he considered some new obstacle opposed to the triumph of truth.

The government of France, at the time when it was seeking to restore some activity to public instruction, proposed to Haüy the preparation of a treatise on physics, for the use of colleges. He had more than one title to this commission, whether from the ingenious manner in which he had applied physics to mineralogy, his many interesting memoirs on the electricity and double refraction of minerals, the elegant exposition which he had given of the theory of *Æpinus* on electricity and magnetism, or the success which had attended the course of physics delivered at the Normal School, established by the Convention in 1795. Notwithstanding these titles, however, Haüy scrupled to abandon, even for a time, the successful researches to which, as he thought, he had been guided by the hand of Providence, nor did he enter on the task without first consulting the Abbé Emery, a former superior of St. Sulpice. "Do not hesitate," said the latter; "it will be your own fault, if, in treating of nature, you neglect to speak of its Author; and fail not to designate yourself on the title page a Canon of the Metropolis." The abbé, whose ability is to be as little questioned as his sincerity, knew that there is no profession which is not exalted by the talents of those who exercise it, and remembered, doubtless, that the epoch when Christianity made most conquests and its ministers were held in most respect, was that when the latter carried the light of letters among the nations they converted, and by the union of these with the truths of religion constituted themselves at once the most eminent and most enlightened order of the State.

If this treatise on physics added little to the scientific reputation of its author, it by no means impaired his literary standing. Marked by the same clearness and purity of style as his mineralogy, it possesses even more interest; it is a book eminently qualified to inspire youth with a taste for the natural sciences, and to be received with interest by all. Hence, it soon passed to a third edition.

At different times Haüy had been warmly pressed to designate some post for himself, adapted to his pursuits and inclination. As his wishes extended no further than to be enabled to bring his family around him, as a solace in age and infirmity, this object seemed to be accomplished by the appointment of the husband of his niece to a petty place in the public revenues. But, strange to say, this slight recompense disappeared at the next reform, and no other answer to the remonstrances of Haüy's friends could be obtained but that there seemed to be no relation between crystallography and taxation.

Newton, it will be remembered, had in like manner been recompensed for the glory which his genius shed upon his country, by an appointment (far more considerable, it is true) of a financial nature; but he kept it under three kings and ten ministers. How is it that the men

who dispose, commonly for so short a time, of the lots of others, forget so often that acts like these will find a more enduring place in history than all the ephemeral details of their administration?

Nor was this the only trial that Haüy had to encounter. A short time afterwards the regulations of finance caused him the loss of his pension, as being incompatible with a salary for actual services; while his brother, who had been attracted to Russia with a view to the instruction of the blind, returned without the fulfillment of the promises held out to him, and with health so shattered as to be thrown entirely on his family for support.

Thus it was that, towards the end of his life, Haüy saw himself suddenly reduced to the strictly needful, of which he had before had experience. It would have required all his pious resignation to support this reverse, but for the care used by his young relatives to dissemble their own concern for his misfortunes. They redoubled their attentions as his means of acknowledgment diminished, and in recompense might find consolation in the devotion manifested by his pupils and the respect borne him by all Europe. Enlightened men, of whatever rank, arriving at Paris, hastened to tender him their homage; even the day before his death the heir of a great kingdom was to be seen sitting by his pillow and evincing his interest by expressions of the most touching sympathy. But to Haüy it was a more solid ground of support that, in the midst of his honors and prosperity, he had quitted none of the habits of his college, or even of his native village. His hours of repast, as well as of rising and lying down, were the same; each day he took nearly the same exercise, and in the same places, and while doing so still contrived to manifest his kindness by conducting strangers who were at a loss, or by giving them tickets of admission to the collections. Many have received these little attentions who never suspected from whom they proceeded. His old-fashioned attire, his simple air, his language, (always of an excessive modesty,) were not likely to cause his recognition. His former townsmen, when he visited the place of his birth, could little divine from his deportment how considerable a personage he had become at Paris. It may be mentioned, as characteristic, that on one occasion, having met two old soldiers who were going out for a fight, he inquired into the subject of their quarrel, brought about a reconciliation, and, to make sure that the dispute would not revive, went with them to seal the peace after military fashion—at the ale-house.

The extreme simplicity of his habits would have probably prolonged his life, notwithstanding the frailty of his constitution, had not an accident accelerated the fatal event. A fall which he met with in his chamber fractured the neck of his thigh, and an abscess forming in the articulation rendered the injury incurable. During the long sufferings which preceded his death, he ceased not to exhibit the same gentleness, the same pious submission to the decrees of Providence, the same ardor for science, which had characterized his life. His time was divided between prayer, the superintendence of a new edition of his book, and a zealous solicitude for the future welfare of the students who had assisted him in its preparation.

He died the 3d of June, 1822, at seventy-nine years of age, leaving his family but one legacy—a magnificent one, it is true—in that precious collection of crystals of every variety, which the contributions of all Europe, during twenty years, had enhanced to a degree of which there is no equal.

He was succeeded in each of his places by one of his own pupils; by Brongniart at the Museum of Natural History, Beudant in the Faculty of the Sciences, and Cordiër in this Academy. It may be added, indeed, by way of worthily closing this account of his life and labors, that it would be difficult to find in Europe, at this day, a mineralogist worthy of the name, who, if not actually a pupil of Haüy, may not be considered such by the assiduous study of his works and his discoveries.



## NOTICES OF THE PROGRESS OF OUR KNOWLEDGE REGARDING THE MAGNETIC STORMS.

BY MAJOR GENERAL EDWARD SABINE, R. A.

FROM THE PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON, VOL. X.

It may not be unsuitable on the present occasion to take a brief retrospective view of the progress of our knowledge respecting these remarkable phenomena, *videlicet*, the *casual magnetic disturbances* or *magnetic storms*. Antecedently to the formation of the German Magnetic Association, and the publication of its first annual report, in 1837, our information concerning them went no further than that there occurred at times, apparently not of regular recurrence, extraordinary agitations or perturbations of the magnetic needle, which had been noticed in several instances to have taken place *contemporaneously* in parts of the European continent distant from each other, and to have been accompanied by remarkable displays of aurora, seen either at the locality itself where the needle was disturbed, or observed contemporaneously elsewhere. The opinion which appears to have generally prevailed at this time was, that the aurora and the magnetic disturbances were kindred phenomena, originating probably in atmospherical derangements, or connected at least in some way with disturbances of the atmospherical equilibrium. They were classed accordingly as "Meteorological Phenomena," and were supposed to have a local, though it might be in some instances a wide extension and prevalence.

The special purpose of the German Magnetic Association was to subject the "*irregular magnetic disturbances*" (as they were then called in contradistinction to the regular periodical and secular variations) to a more close examination, by means of systematized observations made simultaneously in many parts of Germany. With this view, six concerted days in each year were set apart in which the direction of the declination magnet should be observed with great accuracy by methods then for the first time introduced, at successive intervals of five minutes for twenty-four consecutive hours, the meteorological instruments being observed at the same time. The clocks at all the sta-

tions were set to Göttingen mean time, (Göttingen being the birth-place of the association,) and the observations were thus rendered strictly simultaneous throughout. The high respect entertained for the eminent persons with whom the scheme of the association originated, obtained for it a very extensive coöperation, not limited to Germany alone, but extending over a great part of the European continent. The observations of the "Term-days," as they were called, were maintained until 1841, and were transmitted to Göttingen for coördination and comparison.

The principal results of this great and admirably conducted coöperative undertaking were published in works well known to magneticians. They may be summed up as follows: The phenomena which were the subjects of investigation were shown to be of casual and not regular occurrence; to prevail contemporaneously everywhere within the limits comprehended by the observations; and to exhibit a correspondence surprisingly great, not only in the larger, but even in almost all the smaller oscillations; so that, in the words of the reporters, MM. Gauss and Weber, "nothing, in fact, remained which could justly be ascribed to *local* causes."

Equally decided were the conclusions drawn against the previously imagined connection between the magnetic disturbances and derangements of the atmosphere, or particular states of the weather. No perceptible influence whatsoever on the needle appeared to be produced either by wind-storms or thunder-storms, even when close at hand.

The correspondence in the simultaneous movements of the declination magnet, so strikingly manifested over an area of such wide extent was, however, more remarkable in respect to the *direction* of a perturbation than to its *amount*. The disturbances at different stations, and even, as was expressly stated, at *all* the stations, coincided, even in smaller instances, in time and in direction, but *with dissimilar proportions of magnitude*. Thus it was found generally that by far the greater number of the anomalous indications were smaller at the southern stations and larger at the northern; the difference being greater than would be due to the difference in the antagonistic retaining force, (*i. e.*, the horizontal force of the earth's magnetism, which is greater at the southern than at the northern stations.) The generality of this occurrence led to the unavoidable inference that in Europe the energy of the disturbing force must be regarded weaker as we follow its action towards the south.

A close and minute comparison of the simultaneous movements at stations in near proximity to each other led to the further conclusion, also stated to be unavoidable, that "various forces must be admitted to be contemporaneously in action, being probably quite independent of each other, and having very different sources; the effects of these various forces being intermixed in very dissimilar proportions at various places of observation, according to the directions and distances of these from the sources whence the perturbations proceed." (*Resultate aus den Beob. des Mag. Vereins*; 1836, pp. 99, 100.) The difficulty of disentangling the complications which thus occur at every individual station was fully foreseen and recognized; and the report, which bears

the initial of M. Gauss, concludes with the remark that "it will be a triumph of science, if at some future time we should succeed in reducing into order the manifold intricacies of the combinations, in separating from each other the several forces of which they are the compound results, and in assigning the source and measure of each."

Such was the state of the inquiry when it was entered upon by the Royal Society. The report of the Committee of Physics, drawn up (*inter alia*) for the guidance of the Magnetic Observatories established by her Majesty's government for a limited period in four of the British colonies, bears date in 1840. The objects proposed by this report were a very considerable enlargement upon those of the German Association, as well as an extension of the research to more distant parts of the globe. The German observations had been limited, for the most part, to one only of three elements required in a complete investigation. When the German Association commenced its operations, the declination was the sole element for which an apparatus had been devised capable of recording its variations with the necessary precision. To meet the deficiency in respect to the horizontal component of the magnetic force, M. Gauss constructed, in 1837, his bifilar magnetometer, which was employed at Göttingen, and at some few of the German stations, concurrently with the declinometer, in the term observations of the concluding years of the association. But an apparatus for the corresponding observations of the vertical portion of the force was, as yet, wholly wanting; without such an apparatus as a companion to the bifilar, no determination could be made of the perturbations or momentary changes of the magnetic dip and force; and, without a knowledge of these, no satisfactory conclusion in regard to the real nature, amount, and direction of the perturbing forces could be expected. The ingenuity of Dr. Lloyd supplied the desideratum by devising the vertical-force magnetometer, which, with adequate care, has been found scarcely, if at all, inferior to the bifilar in the performance of its work. The scheme of the British observatories was thus enabled to comprehend all the data required for the investigation of the casual disturbances, whether that investigation was pursued as before by concerted simultaneous observations at different stations, or, as suggested in the report, *by the determination of the laws, relations, and dependencies of the disturbances at individual stations, obtained independently and without concert with other observers or other stations.* Thus, in reference to these particular phenomena, the British system was both an enlargement and an extension of the objects of the German Association; but it also embraced within its scope the determinations with a precision, not previously attempted, of the *absolute values* of the three elements, and of *the periodical and progressive changes* to which they are subject; premising, however, and insisting with a sagacity which has been fully justified by subsequent experience, on the necessity of eliminating, in the first instance, the effects of the casual and transitory variations, as an indispensable preliminary to a correct knowledge and analysis of the progressive and periodical changes. A further prominence was given to investigations into a particular class of phenomena, which form the subject of this paper,

by the declaration that "the theory of the transitory changes is in itself one of the most interesting and important points to which the attention of magnetic inquirers can be turned, as they are, no doubt, intimately connected with the general causes of terrestrial magnetism, and will probably lead us to a much more perfect knowledge of these causes than we now possess."

The instructions contained in the Royal Society's report for the adjustment and manipulation of the several instruments provided for these purposes, were clear, simple, and precise. In looking back upon them after the completion of the services for which they were designed, it is impossible to speak of the instructions otherwise than with unqualified praise. But the guidance afforded by the instructions terminated with the completion of the observations. To have attempted to prescribe the methods by which conclusions, the nature of which could not be anticipated, should be sought out from observations not yet made, would have been obviously premature. Yet without some discussions of the results, the mere publication of unreduced observations is comparatively valueless. It has been well remarked by eminent authority, whose opinions expressed in the Royal Society's report have been frequently referred to in the course of this paper, that "a man may as well keep a register of his dreams as of the weather, or *any other set of daily phenomena*, if the spirit of grouping, combining, and eliciting results be absent." It was indispensable that the attempt should be made to gather in at least the first fruits of an undertaking on which a considerable amount of public money and of individual labor had been expended; and the duty of making the attempt might naturally be considered to rest on the person who had been intrusted with the superintendence of the Government observatories. The methods and processes adopted for reducing, combining, eliminating, and otherwise eliciting results, were necessarily of a novel description; they were, in fact, an endeavor to find a way by untrodden paths to simple and general phenomenal laws, where no definite knowledge of the origin or mode of causation of the phenomena previously existed. Happily, it is not necessary to trespass on the time or attention of the society by a description of the methods and processes which have been employed to elucidate some of the leading features of the magnetic storms, as these are fully described in the discussions prefixed to the ten large volumes in which the observations at the colonial observatories have been printed. It will be only necessary to advert, and that very briefly, to some of the principal conclusions which may be supposed to throw most light on the theory of these phenomena.

The results of the extension of the term-day comparisons to the American continent, and to the southern hemisphere and the tropics, may first be disposed of, in a very few words. The contemporaneous character of the disturbances which had been shown by the German term observations to extend over the larger portion of the European continent, manifested itself also in the comparisons of the term-days in 1840, 1841, and 1842, at Prague and Breslau, in Europe, and Toronto and Philadelphia, in America, published in 1845; and the same

conclusion was obtained by comparing with each other the term-days at the colonial observatories, situated in parts of the globe most distant from one another. The days of disturbance still appeared to be of casual occurrence, but were now recognized as affections common to the *whole globe*, showing themselves simultaneously at stations most widely removed from each other. When distant stations were compared, as, for example, stations in Europe with those of America, and either or both with Tasmania, discrepancies in the amount of particular perturbations, similar to those which had been found in comparing the European stations with each other, presented themselves, but larger and more frequent, and extending occasionally even to the *reversal* of the *direction* of the simultaneous disturbance. Instances were not unfrequent of the same element, or of different elements, being disturbed at the same observation-instant in Europe and America; and on the other hand, there were perturbations, sometimes of considerable magnitude, on the one continent, of which no trace was visible on the other. Hence it was concluded, with the increased confidence due to this additional and more extensive experience, that various forces proceeding from different sources were contemporaneously in action; and it was further inferred that the most suitable and promising mode of pursuing the investigation was by an endeavor to analyze the effects produced at individual stations, and to resolve them, if possible, into their respective constituents.

The hourly observations which had been commenced at the colonial stations in 1841 and 1842, and continued through several subsequent years, furnished suitable materials for this investigation, the first fruits of which were the discovery that the disturbances, though casual in the times of their occurrence, and most irregular when individual perturbations only were regarded, were, in their *mean* effects, *strictly periodical phenomena*; conforming, in each element and at each station, on a mean of many days, to a law dependent on the solar hour; thus constituting a systematic mean diurnal variation distinct from the regular daily solar-diurnal variation, and admitting of being separated from it by proper process of reduction. This conformity of the disturbances to a law depending on the solar hours was the first known circumstance which pointed to the sun as their primary cause, while at the same time a difference in the *mode* of causation of the regular and of the disturbance-diurnal variations seemed to be indicated by the fact that in the disturbance-variation the local hours of maximum and minimum were found to vary, (apparently without limit,) in different meridians, in contrast to the general uniformity of those hours in the previously and more generally recognized regular solar-diurnal variation.

This first reference of the magnetic storms to the sun as their primary cause was soon followed by a far more striking presumptive evidence of the same; by a further discovery of the existence of a periodical variation in the frequency of occurrence and amount of aggregate effects of the magnetic storms, corresponding in period and coincident in epochs of maximum and minimum with the decennial variation in the frequency and the amount of the spots on the sun's

disk, derived by Schwabe from his own systematic observations commenced in 1826, and continued thenceforward. The decennial variation of the magnetic storms is based on the observations of the four widely distributed colonial observatories, and is concurred in by all. This remarkable correspondence between the magnetic storms and physical changes in the sun's *photosphere*, of such enormous magnitude as to be visible from the earth even by the unassisted eye, must be held to terminate altogether any hypothesis which would assign to the cause of the magnetic disturbances a local origin on the surface or in the atmosphere of our globe, or even in the terrestrial magnetism itself, and to refer them, as cosmical phenomena, to direct solar influence, leaving for future solution the question of the *mode* in which that influence produces the effects which we believe we have thus traced to their source in the central body of our system.\*

We may regard as a step towards this solution the separation of the disturbances of the declination into two distinct forces acting in different directions and proceeding apparently from different foci: the phenomena of distinct (though in so many respects closely allied) variations exhibit the same peculiar features at all the stations to which the analysis has hitherto extended, and have been exemplified by the observations at Kew, as shown in the early part of this paper. A similar separation into two independent affections, each having its own distinct phenomenal laws, has followed from an analysis of the same description applied to the disturbances of the magnetic dip and force at the colonial stations; thus placing in evidence, and tracing the approximate laws of the effects of six distinct forces (two in each element) contemporaneously in action in all parts of the globe, and pointing in no doubtful manner to the existence of two terrestrial foci or sources in each hemisphere from which the action of the forces emanating from the sun and communicated to the earth may be conceived to proceed. Such an ascription naturally suggests to those conversant with the facts of terrestrial magnetism the possibility that Halley's two terrestrial magnetic foci in each hemisphere may be either themselves the localities in question, or may be in some way intimately connected with them. The important observations which we owe to the zeal and devotion of Captain Maguire, R. N., and the officers of H. M. S. Plover, have made us acquainted with Point Barrow as a locality where the magnetic disturbances prevail with an energy far beyond ordinary experience,

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\*The existence of a decimal period of the magnetic storms was not, as some have supposed, a fortuitous discovery; but a consequence of process of examination early adopted and expressly devised by the employment of a *constant* separating value, to make known any period of longer or shorter duration which might fall within the limits comprised by the observations. The period being decennial and the epoch of minimum occurring at the end of 1843, or beginning of 1844, the epoch of maximum was necessarily waited for in order to ascertain the precise duration of the cycle. The maximum took place in 1848 and 1849, the observations in 1850 and 1851, showing that aggregate value of annual disturbances was again diminishing as it had been in 1842 and 1843. The process of determining the proportion of disturbance in different years is a somewhat laborious one, and requires time: but in March, 1852, I was able to announce to the Royal Society the existence of a decimal variation, based on the concurrent testimony of the observations at Toronto and Hobarton, deeming it proper that so remarkable a fact should not be publicly stated until it had been thoroughly assured by independent observations at two very distant parts of the globe.

indicating the proximity of that station to the source or sources from which the action of the forces may proceed. Now, Point Barrow is situated in a nearly intermediate position between what we believe to be the present localities of Halley's northern foci, and at no great distance from either; in such a situation the exposure to disturbing influences proceeding from both might well be supposed to be very great. The displays of aurora at Point Barrow exceed also in numerical frequency any record received from any other part of the globe.

The further prosecution of this investigation appears to stand in need of some more systematic proceeding than would be supplied by the uncombined efforts of individual zeal. Observations similar to those of the Kew observatory, made at a few stations in the middle latitudes of the hemisphere, disturbed with some approach to symmetry in their longitudinal distances apart, would probably furnish data which, by their combination, might serve to assign the localities from whence the disturbances are propagated, contribute still further to disentangle the complications of the forces which produce them, and thus hasten the attainment of that "triumph of science" foreseen and foreshadowed by the great geometrician of the last age. Of such a nature was the scheme contemplated by the joint committee of the Royal Society and British Association, and submitted to her Majesty's government in the hope of obtaining their aid in the execution of such part of it as fell within British dominion; and of thus "maintaining and perpetuating our national claim to the furtherance and perfecting of this magnificent department of physical inquiry. (Herschel, in *Quarterly Review*, September, 1840, p. 277.) The scheme was no unreasonable one. Probably eight or nine stations in the contour of the hemisphere might suffice; and of these we already possess the observations at Toronto; those at Kew are in progress; and self-recording instruments, similar to those at Kew, are now under verification at Kew preparatory to being employed on the western or Pacific side of the United States territory, at a point not far from the previously-desired station of Vancouver Island, for which a substitute is thus provided. This observatory, as well as one at Key West, on the southern coast of the United States, in which self-recording instruments are already at work, will be maintained under the authority and at the expense of the American government, and both have been placed under the superintendence of the able and indefatigable director of the Coast Survey, Dr. Alexander Dallas Bache. The Russian observatory at Pekin, the trustworthy observations of which are already known to the society, is understood to have recommenced its hourly observations, and stands only in need of an apparatus for the vertical force (which might be readily supplied from this country) to contribute its full complement to the required data. More than half the stations may therefore be regarded as already provided for; and there are other Russian observatories in the desired latitudes and longitudes which might be completed with instruments for a full participation.

It would be wrong to conclude these imperfect notices without recognizing how greatly the researches have been aided in their progress by their united, unflinching countenance and support of the Royal So-

ciety and of the British Association. The Kew observatory owes its existence and maintenance to funds most liberally supplied from year to year by the British Association; and the cost of the self-recording magnetic instruments, of which the first installment of the results has formed the early part of this paper, was supplied from funds at the disposal of the Council of the Royal Society. Magnetical science, rapidly as it is advancing, is even yet in its infancy; and it is in their early stages particularly that all branches of natural knowledge stand in need of the fostering aid of societies, in which science is valued and cultivated for its own sake.



# METEOROLOGY.

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## ON THE DISAPPEARANCE OF ICE.

BY R. H. GARDINER.

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GARDINER, ME., *September 30, 1859.*

At the recent meeting of the Scientific Association at Springfield, Colonel Totten suggested an explanation of the sudden disappearance of the ice on Lake Champlain in the spring of the year. I am induced to state some facts which may throw light on the subject, and explain the reason why ice disappears in such a sudden manner from our ponds and lakes, when it does not do so from our rivers.

The snow in this vicinity accumulates during the winter; till towards its close, it is usually from three to four feet in depth. The ice, with the weight of this snow, sinks below the surface; and the water, rising by capillary attraction, wets the snow, which is then frozen into a mass of *white ice*. Ice formed thus, or by the drippings of a pump, or by water flowing slowly over a frozen surface, is called *white ice*, and is always opaque. *Black ice*, on the contrary, is always translucent, and almost transparent, and is regularly crystallized. These two kinds of ice are dissolved very differently. The mean opening of Kennebec river, for the last seventy-five years, is the 6th of April. Before this date, the strength of the current of the river has worn away the black ice beneath, and the white ice is broken up and carried down in masses, continually growing smaller by attrition. The ice on our ponds and lakes, where there is no current, remains nearly a month later, during which time the superficial white ice is melted by the warmth of the weather, leaving the black ice exposed; and the first hot sun, piercing through the ice, disintegrates it, throwing it into long acicular crystals, which may be sometimes seen heaped upon the shore for two or three days before they entirely disappear. In the year 1842 the ice disappeared from Kennebec river in a similar manner, a circumstance of very rare occurrence. There had been but little snow during the winter, and no sleighing after the 21st of January. There was, therefore, but very little white ice formed on the channel of the river. On the 19th of March, in that year, the thermometer rose to 60° of Fahrenheit, and on the 20th, to 52°. The hot sun of those two days penetrated the exposed black ice, resolved it into crystals, and the white ice from the flats above floated down with the current. So, if two blocks of ice, one black and the other white, be taken from the water and exposed to a hot sun, the former will in a short time be disintegrated and fall into crystals; while the latter will remain solid, only being diminished in size by the melting of its surfaces.

Ice exhibits other phenomena not generally noticed, an account of some of which may be interesting. Ice, as is well known, expands in freezing; but when once frozen, is governed by the same laws as all other solid bodies. Its alternate contraction and expansion produces the same effect of motion upon the ice of our frozen ponds and rivers as is produced by similar causes upon the glaciers of Switzerland. The first increase of cold, after they are frozen, causes the ice to contract and crack with a loud report. These cracks are generally only superficial, but always extend from shore to shore. A mild day expands the ice, and at the same time fills these cracks with water, which freezing, still further enlarging the mass, causes it to press with great force upon the shore, tearing up the ground, and heaving the ice into high ridges. Once at the north end of Winthrop pond, which is nine miles in length, and should be called a lake, I saw a tree fifteen or sixteen inches in diameter, which had been forced up by the roots, and removed by the ice several feet from the place of its original growth. The ebbing and flowing of the tide tends still further to increase the ridges on Kennebec river; for the ice on the flats remains stationary, while the channel ice separates from it as the tide ebbs; and when the tide flows again, the space is filled with water to be frozen, still increasing the mass and enlarging the ridges which are formed between the flats and the channel ice. The ridges are not uniform on the two sides of the river, but are always highest where the pressure of the current is greatest; and wherever there are roads on to the river, these ridges have to be cut down and bridged over with timber and plank. The ridges thrown up on Moose Head lake, the source of Kennebec river, are much more remarkable. The following account of them is derived principally from a person of veracity, who has spent eighteen winters encamped on one of the islands in the lake, surveying the logs cut on its margin to be floated to the mills below. His account is confirmed by other persons whose business has led them to spend a few days every winter on the lake. Upon the first thaw after the lake is frozen, and which usually occurs early in January, ridges are thrown up across the lake with a very loud report, compared by some persons to an earthquake, by others to very loud thunder. Owing to the precipitous character of the shores of the lake, these ridges are not formed, as in our ponds, on its margin, but across the lake, and always extend from shore to shore. The two principal ridges are formed from year to year from the same points. Smaller ridges appear in other places. These ridges are never thrown up in severely cold weather, but during, or immediately after, a thaw. As the season advances they increase in height till they sometimes rise eight or ten feet above the surface of the lake, and have to be cut down to admit passing over them. Towards the close of winter they become weakened by the mild weather, and sink into the lake, where they are dissolved, leaving an open space across the lake from fifteen to twenty feet in width, and which the lumber men are obliged to cross in boats. The person above referred to told me of another singular circumstance; that a strong wind raises the water at the end to which it blows, as high when the lake is covered with ice as when it is free from it. This seemed to me so remarkable, that I questioned my informant how he knew this to

be the case. He replied, that during his first wintering on the lake, a violent northwest gale lasted several days, and the water so entirely disappeared from the north end of the lake, that it was difficult to water the cattle; that the northwest gale was succeeded by a high wind from the south, when the water returned, and was heaped up at the north end of the lake, from which it had disappeared.

Another phenomenon which at first seems unaccountable, is really of easy solution. The outlets of our large ponds are covered with strong ice in the early winter, which is dissolved as the cold becomes more intense, and they remain a long time free from ice; sometimes all winter. The obvious reason is, that our large ponds are kept, by the wind agitating their surfaces, from freezing, long after they have been cooled below the freezing point. The water thus cooled passing into a sluggish stream, is soon converted into ice; but as soon as the cold has become sufficiently intense to counteract the agitation of the water, the pond freezes, and the water issuing from it has acquired nearly the temperature of the earth, and thaws out the stream issuing therefrom.

Anchor ice, which in very severe weather interferes so much with the operation of the mills, is formed in streams cooled much below the freezing point, but where a strong current prevents the regular formation of ice. In making salt, copperas, and in similar operations, when the body is ready to pass from a fluid to a solid state, the process is hastened by throwing a stick into the basin or vat, about which the crystals immediately commence forming. The stones in the bottom of the stream and the poles in the rack in a mill-race answer the same purpose. The ice crystallizes upon them, and increases by agglomeration, till the flow of water is greatly impeded in its course. Ice crystals are formed in early winter, immediately beneath the surface of moist ground, and shoot up two or three inches above the surface, and are sometimes called anchor ice; but their formation depends upon different causes.

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## DIFFERENCE OF TEMPERATURE IN DIFFERENT PARTS OF THE CITY OF ST. LOUIS, MISSOURI.

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BY A. FENDLER.

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It is a generally acknowledged fact that in one and the same neighborhood, the temperature of the open country is somewhat lower than that of the city, and it is chiefly on this account that the former is preferred as a place of residence during the heat of the summer season. But it may not be so well known that, within the boundaries of the same city, at stations not quite two miles apart, this difference of temperature amounts frequently to  $8^{\circ}$ ,  $10^{\circ}$ , or even  $11\frac{1}{2}^{\circ}$ , and that the mean temperature of the year may be  $1^{\circ}.4$  higher in one place than in the other.

We find these facts among some of the results elicited on comparing my meteorological registers for 1859 with those of Dr. G. Engelmann,

who resides in one of the more central parts of the city, in a somewhat high and dry locality; while my own station is about two miles further west. The latter is situated on one of the gentle slopes of Rock Spring Creek valley, which forms a shallow depression of the ground, stretching west and east. The station itself may be considered on or near the same level with that of Dr. Engelmann's, as Rock Spring creek has in its course a pretty rapid descent towards the east. To the west and north I have an open prairie before me; and to the south, some scattered houses. It is only towards the east that the view is obstructed by rows of buildings not far off. The thermometers used on both stations are standard instruments.

From a comparison of the tables of temperature of the two different places, the following facts present themselves in strongly marked features:

1. Of the 1,029 observations, made at the usual hours of 7 a. m., 2 p. m., and 9 p. m., 331, or about one third of the whole, agree near enough with those of the city.

2. The monthly means of the differences of temperature of the two stations show that in the central part of the city the temperature is considerably higher than that of the city limits, as exhibited by the following numbers.

Month.	7 A. M.	2 P. M.	9 P. M.	Mean.
February .....	1.3	0.0	1.5	0.9
March .....	1.1	0.8	1.2	1.0
April .....	0.4	0.7	1.7	0.9
May .....	1.7	0.4	1.7	1.3
June .....	2.1	0.9	2.1	1.7
July .....	2.9	0.4	3.7	2.3
August .....	2.5	0.1	3.3	2.0
September .....	2.2	0.3	2.1	1.5
October .....	3.3	0.2*	3.4	2.2
November .....	1.3	0.1	1.5	0.9
December .....	1.5	0.2	1.3	1.0
Mean .....	1.8	0.3	2.1	1.4

\* Cooler.

3. The greatest, as well as the most numerous differences of temperature, are found in the morning and evening; while at 2 p. m., these differences, if any, are, generally speaking, but very small.

4. During the warmer half of the year, from May to October inclusive, the mean difference, viz:  $1^{\circ}.8$ , is exactly double that of the colder half of the year, which is  $0^{\circ}.9$ .

5. The mean difference of the evenings for the five months, from June to October inclusive, amounts to  $2^{\circ}.9$ , or nearly  $3^{\circ}$ ; and that of the mornings to  $2^{\circ}.6$ ; so that the city limits have, during the warmer months, the benefit of cooler nights and mornings; while at 2 p. m., during the same period of the year, the difference is but  $0^{\circ}.03$ .

6. Near the city limits the latest frost in the spring occurred seventeen days later, and the earliest frost in the fall nineteen days earlier, than in town, hereby shortening the season of no frosts by thirty-six days in the former place. The vegetation in the more central part of

the city has, therefore, a better chance to escape the injuries of late spring and early fall frosts than the adjacent country by thirty-six days. While the former enjoys a period of 204 days without frost, the latter must be satisfied with one of but 168 days, or a period by one sixth less.

On the morning of the 23d of April, the day on which the latest spring frost occurred here, the thermometer marked 32° at 5.15 a. m., and 39° at 7 a. m. On the morning of the 9th of October, the day of the earliest fall frost, the thermometer marked 28° at 6 a. m., and 32½° at 7 a. m.; while Dr. Engelmann's gave 42½° at 7 a. m.

7. The monthly means of clearness and calmness combined are found to be in proportion to those of the differences of temperature between the two places of observation, with only some very slight modifications, as seen by the results of the following table, where the numbers of calms are multiplied by the means of clearness:

Month.	Clearness.	Calm.	Product of Multiplication.	Mean difference of temperature.	Month.
July .....	6.2	× 23	= 1426	2.3	July.
October .....	6.9	× 17	= 1173	2.2	October.
August .....	5.8	× 20	= 1160	2.0	August.
June .....	4.8	× 19	= 912	1.7	June.
{ May .....	4.6	× 15	= 690	1.5	September. }
{ September .....	4.0	× 12	= 480	1.3	May. }
March .....	4.0	× 9	= 360	1.0	March.
April .....	4.2	× 8	= 336	1.0	December
November .....	4.1	× 8	= 328	0.9	November.
February .....	3.7	× 8	= 296	0.9	February.
December .....	4.3	× 6	= 258	0.9	April.

In trying to account for the facts mentioned above, several causes could be named as contributing more or less towards the differences of temperature. But the preceding table seems, more than anything else, to demonstrate that the principal cause of the depression of temperature in these cases is radiation of heat, a most universal and powerful cause, which may, by the interposition of certain mediums, be either retarded in its action or altogether suspended. Such a medium may be found in masses of clouds, as well as in those of smoke, the presence or absence of which may account for most of the differences between the two stations of observation.

We can, therefore, with good reason, assign chiefly to the absence of smoke the lower temperature near the city limits, although it is more than probable that the process of cooling may have been assisted to some extent by the gently sloping sides of the creek valley; for it is well known that the air cooled upon adjacent swells or eminences of the ground, and then gliding down into lower places, does accelerate the cooling action of radiation of the slopes and bottoms.

The inhabitant of a large city, who in his daily walks of business pays little or no attention to the great phenomena of the atmosphere, but who, having heard or read something about radiation of heat towards an unclouded sky, may begin to entertain doubts about these truths of science when distressed with a close and sultry atmosphere

of some calm summer's night, and, sitting upon the doorsteps of his house, he happens to look up towards the zenith of a sky entirely free from clouds. He will perhaps say, now here are all the conditions necessary to a powerful radiation, and yet no relief from this intolerable heat by cooling, which ought to be a natural consequence upon radiation. He may even be apt to compare the atmosphere between his eye and the blue sky to an ether of extreme purity.

But should he take a different position, and view this same atmosphere from a distance outside of the city, he would perhaps pronounce it to be a reservoir of smoke and of all the subtle impurities capable of rising out of the different sources of decomposition and combustion from beneath that great hive of human industry and action. He would, in fact, see a continuous mass of smoke extending from one end of the city to the other, and slowly drifting along or hovering over it, as the case may be. And then, in considering the great influence of large bodies of smoke upon the results of radiation, he may perhaps feel that the truths of science still hold good, and that it was only his own neglect to take another view of the same subject from a different direction in order to discover the real condition of things.

Now, we know it to be a well established fact that strata of smoke, suspended in the air, interfere most effectually with radiation of heat from the surface below.

By analyzing more minutely the evidence contained in our meteorological registers and referring to individual cases more frequently, we may be able to make the great influence of smoke still more apparent.

In order to do this I have divided all those of my observations made at the regular hours of 7 a. m., 2 p. m., and 9 p. m. into five classes.

In the first class, in the annexed table, I have put down all cases where a *clear* sky (cloudiness not exceeding 2) exists in connection with a *calm* atmosphere or very light breezes of velocity 1.

In the second class are to be found all the cases of a more or less clouded sky (cloudiness exceeding 2) existing in connection with *calms* or very light breezes.

In the third and fourth classes all the cases of a *clear* sky (cloudiness not exceeding 2) existing in connection with *brisk* winds are enumerated; in the third, those with winds from west to northwest inclusive, and in the fourth, those with winds from all other directions.

The fifth class comprises all the remaining cases, namely, those of a more or less *clouded* sky (cloudiness exceeding 2) connected with *brisk* winds. The cases of this class being very numerous and of a more uniform character, it is not deemed necessary to give them here in detail.

Clearness of sky and calmness of the atmosphere are the two indispensable conditions for energetic radiation of the heat of the earth's surface, and consequently for the cooling of the lower strata of the atmosphere. But this favorable combination of the two principal conditions we can expect to occur but in a limited number of cases in this part of the Mississippi valley; and, indeed, we find in our register a great many cases where either the clearness of the sky is made ineffective, as to radiation, by the prevalence of brisk winds, or else, where a calm state of the atmosphere is of no avail toward promoting radia-

tion on account of a clouded sky. Besides this, there are numerous instances where clearness and calmness are both wanting at the same time.

Hence if the general result, as exhibited by the mean of the year, is expected to make anything like a show, it is necessary that, amongst such an abundance of counterbalanced cases, the few favorable instances should carry along with them pretty large figures. And this they really do, as may be readily seen from the first class of cases in the annexed table.

*Further remarks on this class.*—In *clear* and *calm* weather without smoke, and other things being equal, the cooling of the lower portion of the atmosphere by radiation ought to go on even somewhat faster in town than in the country; for the thousands of roofs, sending the caloric off against a serene sky, would cool the immediate superincumbent strata of air, which, hereby becoming heavier, sink down upon the pavements and lift the warmer strata upwards, until the latter in their turn are cooled in a similar manner. But not only is the advantage of the city to reduce the temperature in this way counterbalanced in a mechanical way by the strata of smoke gathering above and preventing a rapid ascent of the warmer columns of air; but by this smoke the radiation itself is greatly interfered with, if not altogether stopped. Besides this procedure of keeping the caloric of the city from radiating more freely into space, comes the accumulation of artificial heat from within the houses and shops, from fires, lights, and the presence of hundreds of thousands of living beings. With a calm atmosphere this heat is not easily carried off.

The principal cause of the interference with radiation in a large city, viz., the smoke, is wanting in the open country, and hence the reduction of temperature which here may take place, and, indeed, is found to be considerably lower than in town.

#### *Comparison of temperature at 2 p. m. between city and country.*

It is somewhat remarkable that among the whole number of observations in class No. 1—that is, among 154 instances of combined *clear* and *calm* weather—we can find only seven to occur at 2 p. m.; and in these seven instances the temperature near the city limits is either warmer than that of the town, or only by one half of a degree or at most one degree cooler.

Now, it may be asked, “Why are, in these instances, few as they are, the same effects not produced under similar circumstances at the hour of 2 p. m.?” or, in other words, “Why does, in clear and calm weather, the temperature of the open country, at 2 p. m., not bear the same relation to that of the city as it does at 7 a. m. and 9 a. m.?” Here, however, we must not forget that another new additional factor comes into play at 2 p. m., which is not operating at 9 a. m., and only partially so at 7 a. m., namely, the action of direct rays from the sun upon the surface they may happen to strike.

But how can this cause, which apparently ought to affect equally the open country as well as the city, change the mutual relation of temperature of these two places?

Can it be on account of the layers of smoke above the city enfeebling the action of the sun's rays in passing through, which, as to efficiency in this case, I consider more than doubtful; or is it not rather due to the fact that, upon the pavements in the streets of a compactly-built town, a considerable amount of shade is cast in clear weather, at 2 p. m., from the row of high buildings, which shade is altogether wanting upon an open prairie? While in town the air heated and rarified upon the roofs does not sink down into the streets, and consequently does not affect the surface below, the entire unbroken surface of the prairie, on the other hand, acts as a heating medium at once upon the lowermost portions of the atmosphere. Hence it may be at times even somewhat cooler, at 2 p. m., in town than in the open prairie. Besides this, the customary sprinkling of the streets to lay the dust, and the consequent evaporation, is no doubt helping towards a reduction of temperature.

In the third and fourth classes of the annexed table, where the same condition of clearness as in class No. 1 prevails, with the difference of brisk winds instead of a calm or light breezes, we find a great many cases noted down at 2 p. m.; and hence we can avail ourselves here of a much greater number of instances to illustrate the same principle. Here we have 175 single observations, of which exactly two fifths, namely, seventy instances, came upon 2 p. m.; and here, also, we find the difference of temperature between town and country amounting either to nothing or a mere trifle, while seventeen cases show even a cooler temperature in town. Here, in addition to the above mentioned causes, a briskly moving atmosphere is actively engaged to carry away from the tops of houses the superincumbent layers of air as fast as they are heated by contact with the roofs.

*Unusually small figures among the morning and evening temperatures of Class No. 1.*

But there are also among the morning and evening temperatures in Class No. 1, cases which, by their *small* figures seem to form exceptions to the high figures of all the rest. They have had all the advantages of calmness and clearness of weather, the same as the others, and yet we find no corresponding amount of fall in the thermometer.

There are, in class No. 1, to be found eleven instances not exceeding one degree, four of no difference, and three even warmer than in town. In most of them a very gentle breeze from southeast and south is prevailing; in eight of them we see a rain or thunder storm near at hand; but beyond this the register gives us no key of explanation. It is, however, very probable that radiation in these cases is interfered with by some kind of haze, dust, or vapor interposed between our vision and the zenith, too subtle to be recognized by us from the position we occupy in looking towards it. A cyanometer could no doubt solve the question more satisfactorily. It may not be amiss to mention here, also, that in classes Nos. 3 and 4, of the seventeen instances of *unusually great* differences of temperature, fourteen take place at seven o'clock in the morning, when the air appears to be more refreshing than at any other time of the day, and when it is the very opposite from sultry. This is what we ought to expect.



A few notable instances which bear somewhat upon the preceding subject, and which at first sight seem not to be in accordance with the principles of radiation, we find, on the 2d, 6th, and 7th of November, where, with a light haze (not fog) but otherwise cloudless sky and a calm atmosphere, a great reduction of temperature is seen against that of the city. On the 2d of November, at 7 a. m., the difference of temperature amounts to eight degrees; on the 6th, at 9 p. m., it amounts to five degrees; and on the 7th, at 7 a. m., to nine and a half degrees. These facts might be brought forward against the doctrine of the interference of smoke; for it may be asked, "Why does the haze not interfere with radiation in these cases?"

To this we reply that the dry haze, consisting, as it does, chiefly in minute floating particles of smoke, has slowly settled down to the lower strata of the atmosphere, in consequence of the powerful radiation and cooling of *its own particles*, and may therefore be considered as the *result* of radiation, and not as an interfering medium. But when, after continual additions, the haze has accumulated to such a depth as to prevent the penetration of the radiant heat, then the case will be quite a different one. An instance of this kind we find also in our register, illustrating in a striking manner what we have just said. For while, at 7 a. m. on the 7th of November, with a light haze, a sky free from clouds, and a scarcely stirring breeze from southeast, the temperature fell nine and a half degrees lower than that of the city; by 9 p. m., the haze had grown so thick as to screen the sky completely; and although with a *calm* atmosphere prevailing at this time, the temperature was not in the least cooler, but, on the contrary, was warmer by three degrees than that of the city.

*Class No. 2, namely, that of calms and clouds.*

That with a completely clouded sky and a calm atmosphere it should be warmer in town than in the country, simply from accumulation of heat, can easily be conceived; but why, in many instances, the reverse should take place, and, as shown by the figures in class No. 2, the temperature of the town should sometimes be cooler than that of the country, could not be so easily accounted for if the register itself was not consulted. In class No. 2 we have twenty-three instances where the temperature near the city limits is warmer than that of the city. By reference to the register we find, however, that of these twenty-three cases eighteen have had only partial cloudiness, and therefore offering open passages to the rays of the sun as well as to partial radiation; circumstances capable of modifying the result to a considerable extent. But five have entire cloudiness; and in four out of these remaining five instances we see them associated with rain and thunder storms, while the fifth and last stands between fog and mist.

In regard to most of the instances coming under the head of the fifth class, namely, all those of a *clouded* sky, accompanied by *brisk* and *violent winds*, we find that the mean numbers of the temperature of the city limits differ but very little from those of the central part of the city. This is what may be expected; for the rush of strong winds beneath a clouded sky allows no great accumulation of heat in the streets,

but rather tends, by constantly renewing and intermingling the different columns of moving air, to distribute the heat equally through town and country.

What a decided influence the different conditions of the sky and the motion of the atmosphere have upon the differences of temperature between town and country, appear in a striking manner on comparing the mean numbers of each of the five classes in the annexed table. While the mean number of class No. 1 is  $3^{\circ}.9$ , that of class No. 2 is  $1^{\circ}.8$ ; of class No. 3,  $1^{\circ}.4$ , of class No. 4,  $1^{\circ}.3$ ; and but  $0^{\circ}.5$  in class No. 5.

## FIRST CLASS.

*Containing all the cases where a CLEAR sky (cloudiness not exceeding 2) exists in connection with a CALM atmosphere, or very light breezes of velocity 1.*

Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	Date.	Hour.	Degrees.
February 12	9 P. M.	3	July 16	9 P. M.	3	October 3	7	2
13	7 A. M.	7 $\frac{1}{2}$	17	7 A. M.	W.	9	9 P. M.	5
20	9 P. M.	5 $\frac{1}{2}$	18	9 P. M.	1 $\frac{1}{2}$	4	9 P. M.	1
21	7 A. M.	5 $\frac{1}{2}$	19	7 A. M.	1 $\frac{1}{2}$	5	9 P. M.	5
26	9 P. M.	3	20	9 P. M.	6	6	7 A. M.	8
28	9 P. M.	2	22	9 P. M.	5	8	9 P. M.	5
March 4	9 P. M.	7	23	9 P. M.	5	9	7 A. M.	10
5	9 P. M.	0	24	9 P. M.	2 $\frac{1}{2}$	10	2 P. M.	W.
12	2 P. M.	1	27	9 P. M.	6 $\frac{1}{2}$	14	9 P. M.	4 $\frac{1}{2}$
	9 P. M.	1	31	9 P. M.	3 $\frac{1}{2}$	15	7 A. M.	5
25	9 P. M.	4	August 1	7	3	18	7 A. M.	7
30	9 P. M.	2	4	9	5	19	9 P. M.	6
31	9 P. M.	2	5	7	5	22	9 P. M.	7
April 5	9	6 $\frac{1}{2}$	6	7	5	23	9	5
11	9	3	7	9	4 $\frac{1}{2}$	24	9	2 $\frac{1}{2}$
18	9	0	8	9	7	25	2	4
22	9	4 $\frac{1}{2}$	11	9	3	29	9	1
23	9	2	12	9	4	30	9	7 $\frac{1}{2}$
27	9	2	15	9	6 $\frac{1}{2}$	31	7	6
May 8	9	1	16	9	5	Nov. 2	9	W.
8	7	1	17	9	4 $\frac{1}{2}$	6	9	8
10	9	2	19	9	5	7	9	5
17	9	2	20	9	6 $\frac{1}{2}$	8	9	8
21	9	5	22	9	11 $\frac{1}{2}$	9	9	5
22	9	5	24	9	5 $\frac{1}{2}$	13	9	9 $\frac{1}{2}$
23	9	7	29	9	2	14	9	2 $\frac{1}{2}$
27	9	1 $\frac{1}{2}$	30	9	4 $\frac{1}{2}$	15	9	4 $\frac{1}{2}$
28	9	0	Sept. 1	9	3 $\frac{1}{2}$	21	9	4
31	9	6	2	9	3	22	9	6
June 2	9	6 $\frac{1}{2}$	5	9	3 $\frac{1}{2}$	26	9	2 $\frac{1}{2}$
4	9	6 $\frac{1}{2}$	8	9	4 $\frac{1}{2}$	27	2	W.
6	9	2 $\frac{1}{2}$	11	9	5	7	9	2
9	7	2 $\frac{1}{2}$	16	9	4 $\frac{1}{2}$	8	9	7 $\frac{1}{2}$
19	9	1	22	9	7	9	9	4
30	9	5	24	9	2	10	9	7
21	9	4	29	9	4 $\frac{1}{2}$	11	9	4
24	9	1	30	9	3 $\frac{1}{2}$	12	9	7
25	9	4	Sept. 1	9	3	14	2	1 $\frac{1}{2}$
26	9	2	2	9	3 $\frac{1}{2}$	15	9	1 $\frac{1}{2}$
28	9	2 $\frac{1}{2}$	5	9	3 $\frac{1}{2}$	22	9	1 $\frac{1}{2}$
July 1	9	2 $\frac{1}{2}$	8	9	4 $\frac{1}{2}$	24	9	2 $\frac{1}{2}$
5	9	7	11	9	4 $\frac{1}{2}$	25	9	1
6	7	5	16	9	W.	26	2	0
	9	6	22	9	4	Mean.....	.....	3.9
7	7	1 $\frac{1}{2}$	23	9	W.			
8	9	6	24	9	4			
9	9	5	25	9	5			
10	9	3	30	9	2			
12	9 P. M.	4 $\frac{1}{2}$	October 1	7	4			
	7 A. M.	1	2	9	3 $\frac{1}{2}$			
	9 P. M.	7 $\frac{1}{2}$			4			
13	9 P. M.	4 $\frac{1}{2}$						

SECOND CLASS.

All cases of a more or less CLOUDED sky (cloudiness exceeding 2) in connection with CALMS or very light breezes.

Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	
February	1	3	June	12	$\frac{1}{2}$	Aug.	31	9	$3\frac{1}{2}$
	3	0			0	Sept.	4	9 P. M.	$2\frac{1}{2}$
	4	0		15	0		6	7 A. M.	5
	5	1		17	2			9 P. M.	$6\frac{1}{2}$
	6	4			$\frac{1}{2}$		7	7 A. M.	$\frac{1}{2}$
	8	1			W.			2 P. M.	$1\frac{1}{2}$
	11	0		19	2		8	9 P. M.	2
	15	5		20	$\frac{1}{2}$		13	9 P. M.	8
	16	$3\frac{1}{2}$		22	W.		14	7 A. M.	3
	17	3		23	1		15	9 P. M.	0
	23	2			$\frac{1}{2}$		16	7 A. M.	$\frac{1}{2}$
		$1\frac{1}{2}$		24	3		21	9 P. M.	0
	24	0			W.		22	7 A. M.	0
	25	0		25	$4\frac{1}{2}$		23	7 A. M.	1
	28	1		29	7		24	2 P. M.	0
March	1	2			9		26	2 P. M.	0
	5	7	July	2	9			9	$3\frac{1}{2}$
	7	0		10	7		Oct.	6	9
	8	0		11	9			11	9
	21	1		12	2			12	7
		W.		14	9				9
	23	0		15	2			20	9
	27	2			9			25	$5\frac{1}{2}$
		$4\frac{1}{2}$		16	7			30	4
		$1\frac{1}{2}$		17	2				2
April	3	5		21	8		Nov.	1	7
	4	2			0				2
	13	2		22	3			6	2
		$2\frac{1}{2}$		23	3			8	9
	17	1			1			9	9
	19	4		24	2			11	2
	24	$1\frac{1}{2}$			W.				9
	26	1		25	0			14	7
	28	0		26	3			17	7
	30	$1\frac{1}{2}$			3			19	7
May	1	1		2	$\frac{1}{2}$			22	2
	2	$\frac{1}{2}$			$1\frac{1}{2}$			23	7
	6	5		28	$1\frac{1}{2}$			26	2
	7	0		31	7				9
	8	$2\frac{1}{2}$	August	1	9			27	2
	9	2		2	9			29	7
		W.		3	9			30	7
	10	0		5	9				9
	11	W.		9	9		Dec.	3	9
		1		11	2			5	9
	15	$\frac{1}{2}$		14	9			10	9
	16	3		18	7			16	2
	18	$\frac{1}{2}$		20	2				9
	22	$3\frac{1}{2}$			9			20	9
	25	3		21	2			25	2
		$2\frac{1}{2}$		22	7			26	7
	30	$\frac{1}{2}$		23	9			27	2
	31	W.		25	0				9
June	5	W.		26	2			28	7
	6	W.		27	7			29	7
	8	3			2				2
	9	3		30	$1\frac{1}{2}$				
	11	1		31	7				
		9 P. M.					Mean.....	.....	1.8

THIRD CLASS.

All cases of a CLEAR sky (cloudiness not exceeding 2) in connection with BRISK winds.

Winds from W. to NW.

Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	Date.	Hour.	Degrees.
February	4	7 A. M.	May	21	1	Oct.	18	2 P. M.
		2 P. M.		27	1		22	7 A. M.
	6	7 A. M.		28	2		23	2 P. M.
		1		31	2		26	2 P. M.
	20	7 A. M.		2	7		7	4
		1½		9	2		9	½
	0	22	7	2	2	4		
26	7 A. M.	½	2	7	2	0		
27	2 P. M.	W.	6	2	0	5½		
March	4	7 A. M.	8	7	5	3½		
		2½	19	7	3	2		
	15	7 A. M.	23	7	1	8		
		1	30	2	1½	1		
	19	7 A. M.	2	2	1	0		
		2 P. M.	12	7	1½	W.		
24	2	2	2	2	2	2		
29	9	1½	9	9	2½	0		
30	2	2	13	7	9	2		
31	2	0	24	7	W.	4		
April	2	2	27	7	2	2		
		0	1	2 P. M.	0	W.		
	7	7	2	7 A. M.	1½	5		
		0	5	2 P. M.	½	1		
	14	7	2½	7	7 A. M.	2	1½	
		2	W.	14	2 P. M.	W.	1	
23	2	W.	18	7 A. M.	2	0		
May	19	2				Mean.....	1.4	

FOURTH CLASS.

All cases of a CLEAR sky (cloudiness not exceeding 2) in connection with BRISK winds.

Winds from all directions except those in third class.

Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	
February	7	7 A. M.	May	17	0	July	20	2 P. M.	
		0		19	7		5	27	7 A. M.
	9	7 A. M.			9		1		2 P. M.
		½		23	9		1	7	2 P. M.
	3½	24	2	2	8	2 P. M.			
March	22	2 P. M.	June	2	W.	9	7 A. M.		
	26	7 A. M.		3	7	2½	10	9 P. M.	
		0		4	7	3½	15	7 A. M.	
	3	9 P. M.			2	0	16	2 P. M.	
	4	2 P. M.			7	1	21	9	
		W.			9	2	21	9	
10	7 A. M.		20	2	5	28	9		
12	2 P. M.		26	7	½	10	9		
15	7	0	27	9	3	17	7		
19	9	0		9	1	18	9		
31	2	W.	28	7	1	23	2		
April	7	3	July	1	1	27	9		
		0		3	2	3	3	2	
	12	9			4	9	8	2	
	14	9			5	2	1	W.	
	19	9			9	1	15	2	
		2½			9	1	19	7	
24	2	1		13	7	2			
30	7	1		14	7	9			
May	4	2		15	7	20	7		
		1		15	2	21	9		
	5	7		20	7 A. M.				
		1½							
	6	9	3						
	9	9	W.						

FOURTH CLASS—Continued.

Date.	Hour.	Degrees.	Date.	Hour.	Degrees.	Date.	Hour.	Degrees.
October 31	2	1	Nov. 5	2	W.	Dec. 14	7	1½
November 2	2	0	15	2	1	15	7	1
	9	W.	29	9	1		2	0
3	7	W.	Dec. 7	2	0		24	2
	2	W.	8	2	1		26	9
	9	1	10	2	1			½
4	7	3	13	7	0	Mean.....	.....	1.3

FIFTH CLASS.

*Cases of a more or less CLOUDED sky (cloudiness exceeding 2) connected with BRISK winds.*

The cases of this class, being very numerous and of a more uniform character, it is not deemed necessary to give them here in detail. Mean difference of temperature 0°.5.

BEST HOURS FOR OBSERVATIONS OF TEMPERATURE.

BY PROF. C. DEWEY, LL. D.

The meteorological and physical tables published by the Smithsonian Institution contain much additional proof of the close approximation derived from the daily observations of the temperature at 7 a. m., and 2 and 9 p. m., to the actual mean of the day, month, and especially year.

Presuming this evidence must be highly gratifying to the observers over our country, I have selected the following from the Smithsonian tables, or made the calculations from them for their gratification.

The following is the list of the places, their latitude, and the reduction for mean temperature at the hours of 7, 2, and 9, and for the one fourth of the sum of the observations at 7 a. m., 2 p. m., and 2 (9 p. m.) Inspection shows how very small is the reduction for the last:

Place.	Latitude.	Result at 7, 2, and 9.	Result at 7, 2, and 2, (9.)	Result at 9, 12, 3, and 9.
Philadelphia .....	39 58 N.	-0.39	-0.04	-2.53
Toronto .....				-1.08
Montreal .....	45 30 N.	-0.88	-0.30	
Sitka .....	57 3 N.	-0.28	-0.07	
Boothia Felix, Arctic America.....	69 59 N.	-0.20	-0.02	-0.61
Rio Janeiro.. .....	22 54 S.	-0.36	-0.47	-0.45 R.
Trevandrum, India .....	8 31 N.	-0.32	+0.11	-1.01
Madras, India.....	13 4 N.	-0.13	-0.05	-2.66
Bombay, India .....	18 56 N.	-0.11	+0.05	-2.40
				-1.04

TABLE—Continued.

Place.	Latitude.	Result at 7, 2, and 9.	Result at 7, 2, and 2, (9.)	Result at 9, 12, 3, and 9.
Calcutta, India.....	22 33 N.	-0.28	+0.13	-2.52
Tiflis, Asia.....	41 41 N.	-0.59	-0.11	-1.35
Pekin, China.....	39 54 N.	-0.56	-0.18	
Nertchinsk, Siberia.....	51 18 N.	-0.67	-0.08	
Barnaul, Siberia.....	53 20 N.	-0.81	-0.34	-3.11
Rome, Italy.....	41 54 N.	-0.11	+0.43	-3.62
Padua, Italy.....	45 24 N.	-0.47	-0.09	-2.60
Geneva, Switzerland.....	46 12 N.	-0.76	-0.43	
St. Bernard, Switzerland.....	45 52 N.	-0.50	-0.07	
Kremsmünster, Austria.....	48 3 N.	-0.56	-0.31	
Salsburg, Austria.....	47 48 N.	-0.36	-0.04	
Munich, Germany.....	48 9 N.	-0.63	-0.02	
Salzuffen, Germany.....	52 5 N.	-0.56	-0.22	
Prague, Bohemia.....	50 5 N.	-0.47	-0.29	
Greenwich, England.....	51 29 N.	-0.50	-0.00	
Plymouth, England.....	50 22 N.	-0.17	-0.05	
Brussels, Belgium.....	50 51 N.	-0.43	-0.04	
Mühlhausen, Prussia.....	51 13 N.	-0.65	-0.16	
Utrecht, Holland.....	52 5 N.	-0.67	-0.00	
Berlin, Prussia.....	52 30 N.	-0.58	-0.36	
Göttingen, Hanover.....	51 32 N.	-0.63	-0.07	
Apenrade, Sleswick.....	55 3 N.	-0.52	-0.02	-0.91
Leith, Scotland.....	55 50 N.	-0.26	-0.09	-1.23
Makerstown, Scotland.....	55 36 N.	-0.25	-0.00	
Dublin, Ireland.....	53 23 N.	-0.56	-0.02	
Catharinenburg, Russia.....	56 50 N.	-0.45	-0.16	-2.52
St. Petersburg, Russia.....	59 56 N.	-0.38	-0.09	-1.75
Helsingfors, Russia.....	60 10 N.	-0.83	-0.56	-2.20
Christiana, Norway.....	59 55 N.	-0.52	-0.25	-1.84
Dronheim, Norway.....	63 26 N.	-0.54	-0.25	-1.96
Strait of Kara.....	70 37 N.	-0.29	-0.02	-1.25
Matoschkin Schar, Nova Zembla.....	73 0 N.	-0.20	-0.02	-0.83
St. Helena Island.....	15 55 S.	-0.18	-0.01	
Cape of Good Hope.....	33 56 S.	-0.54	-0.04	
Hobart Town, Australia.....	42 53 S.	-0.81	-0.34	

The close approximation of the mean of observations at 7, 2, and 9, over the world, to the mean of twenty-four observations a day is striking and gratifying.

#### ANEMOMETER.

The following is an account of the anemometer for registering the direction and time of changes of the wind, in operation at the Smithsonian Institution:

It consists principally of a light vertical shaft of wood, or iron gas pipe, A B C, of about twenty feet long, passing through a round hole in the roof of the high tower of the Smithsonian building, and connecting a horizontal vane at its upper end, and a recording pencil moved by a clock at the lower end. This shaft is sustained above the roof in an upright position against the pressure of the wind by a rectangular brace *d*, firmly fastened at its lower extremity. The small cylindrical hole in the roof through which the shaft passes has three window sash rollers fastened into its circumference, to prevent friction

in the rotation of the shaft, and is covered with a tin funnel to shed the rain. The shaft and the vane are fastened together, so that the former turns with the latter. The arrow part of the vane is formed of a rod of round iron three fourths of an inch in diameter, and balanced by a bob of lead. The feather part of the vane is composed of two pieces of pine board about one foot wide, eleven feet long, and half an inch thick. To give the instrument more sensibility in regard to the changes of the direction of the wind, the feather part is bifurcated, as shown in the section *e*.

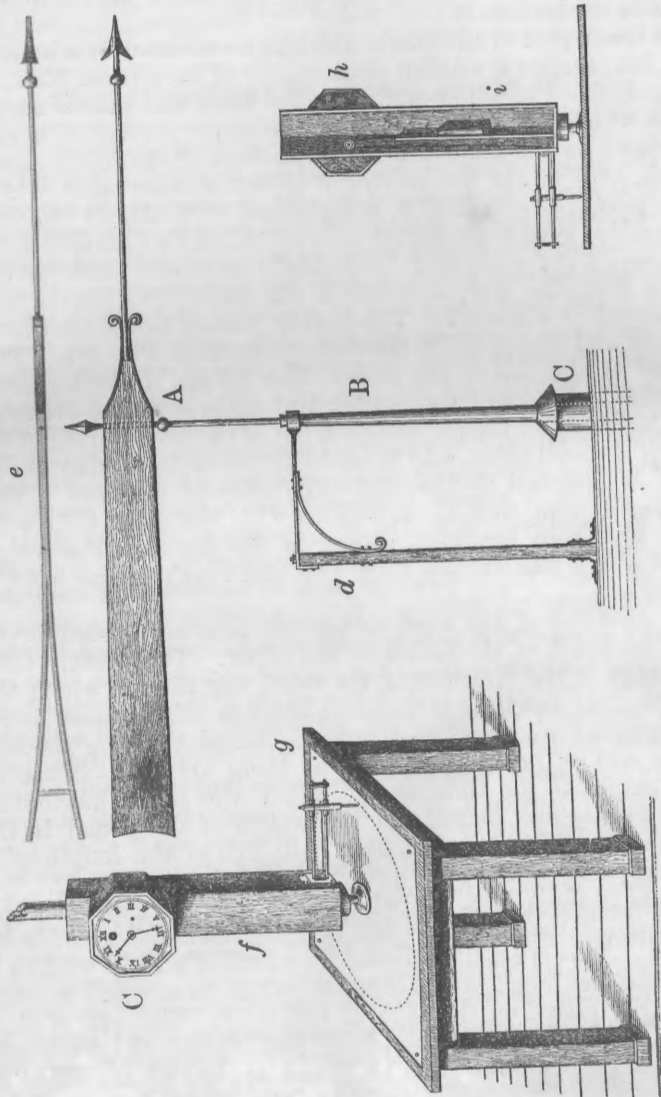
The lower part of the shaft, which is terminated in a hollow rectangular box, carries a wooden clock on one of its vertical faces, as shown in Fig. *Cf*. The whole weight of the shaft and vane is supported on a pivot which rests in a hollow in the upper surface of a small iron disc placed on the middle of the large sheet of recording paper, which in turn, rests on the flat surface of a stout wooden table.

The pencil, as shown at *g*, is supported vertically by two brass tubes which slide, with some degree of friction, on two parallel rods of polished steel wire, projecting horizontally from the shaft, and is drawn inward from the circumference of the paper towards its center by a cord moved by the clock. The hollow part of the shaft which carries the clock and the pencil is shown in section in Fig. *hi*. The cord is fastened at one end to the pencil, then passes under a pulley or friction roller, to change its direction, and again is wound around another pulley fastened on the projecting arbor of the main spring of the clock. To keep the cord tight, and to assist the clock in moving the pencil, a weight is attached to the other extremity of the cord. To prevent this weight from coming in contact with the cord, the two are separated by a thin partition, shown in the figure. The weight is of lead, of about five inches long, two and a half inches wide, and one inch thick.

The direction of the wind at a given time is recorded by the position of the mark of the pencil on the paper. To ascertain the hour of any change in the direction of the wind, the time at which the paper is put on, and the time at which it is taken off the table, is recorded. The distance through which the pencil is drawn during the interval is divided into as many equal parts as there are hours in the interval. For example, if the time during which the paper has been on the table is twenty-four hours, and the motion of the pencil in this time has been twelve inches, then each half inch of the length of the distance moved inwards by the pencil will represent an hour.

To change the paper, the whole shaft with the appended apparatus is lifted up, so that the sheet can be withdrawn and another slid into its place. This is readily effected by means of a light wooden lever of about four feet long; the fulcrum of which is a small wooden block temporarily placed on the edge of the table. One end of this lever, which is forked for the purpose, being placed under the lower end, of the hollow part of the shaft, and the hand applied to the other end, the whole apparatus is elevated sufficiently to allow of the removal of the small iron disc, the withdrawal of the paper, and the insertion of another. To save trouble, and to give a softer surface for the pencil, several layers of paper are put on the table at the same time.

The sides of the table are placed parallel to the cardinal points of the compass, and these are also marked on the edges of the paper, so that at a glance at any subsequent time the direction from which the wind came at a particular date can be determined. The date of each paper is written at the top, and the hour scale calculated for every day. The sheets are of good printing paper, of about two feet in diameter, and are bound in volumes for ready reference.



This apparatus has been in operation for nearly three years and has given entire satisfaction.

J. H.



## NATURAL HISTORY.

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### SUGGESTIONS FOR SAVING PARTS OF THE SKELETON OF BIRDS.

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BY ALFRED NEWTON, OF THETFORD, ENGLAND.

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In the present stage of ornithological knowledge it is not alone sufficient that systematists should be able to describe the external character of a species, but it is required of those who wish really to advance the science, to give some account of the bird's internal structure, also. The subject naturally divides itself into two branches: The first, with regard to the bony framework of the bird; the second, relating to its alimentary and digestive organs. The importance of these latter is very great in determining the proper place of a species in the order of nature, and accordingly they are well deserving of preservation; but it is to the former only that the present remarks are intended to refer. This much is allowed by nearly all ornithologists, that it is very desirable, whenever opportunity offers, to obtain a *complete skeleton* of every species; but it is almost impossible for a field naturalist to do so, except by sacrificing the skin of a specimen, with its skull and feet, which, unless the species be very abundant, is more than can be expected of him. Much, however, may be learned from the examination of some *parts of the skeleton*. It is, therefore, highly important that as great a portion of it as is possible should be saved, and to bring this necessity to the knowledge of the collector, at the same time informing him how it may best be met, is the object of these "suggestions."

It is generally the case that, after having skinned a specimen, the field ornithologist does nothing more with its carcase than, perhaps, to ascertain by dissection its sex, (supposing that the plumage leaves that open to doubt;) though, if he be of a more inquiring disposition, he will look at its crop or stomach to discover upon what it had been feeding. These questions determined, he casts it aside, unless, indeed, he be a needy traveler, in which case the body is consigned, but equally without further thought, to the spit or the kettle. Now, here is a great mistake. The collector in acting thus is, by no means, making the best use of his opportunities; on the contrary, he is neglecting what many ornithologists, who have to stay at home, value most highly; for it is beyond the power of the greatest geniuses, in all cases, to judge rightly of a bird's affinities by the mere study of its feathers, beak, and feet. It is true that, in many cases, they are able to come to a conclusion on this point more or less satisfactory; but it must be remembered that this fact only tells the more to their credit in those instances wherein they determine justly. Often these outward organs are only,

to use the phrase of one of the greatest naturalists of this or any other time, "adapted to certain habits," and do not, *of necessity and alone*, reveal the bird's true position in the system of nature, any more than the binding of a book tells us with certainty what its contents may be.

It is pretty generally admitted among those who have studied the orteology of birds that the most characteristic portions of the ornithic skeletons are the cranium or skull, and the sternal apparatus, or bones of the breast, to which are attached the muscles governing the motions of the wings, and thus serving to support the bird during its flight. Now, though a skillful artist, in his own workshop, may do otherwise, it is, as has been above mentioned, almost impossible for a field collector to preserve the former, except as part and parcel of the skin. But there is not the slightest reason why the latter—the sternal apparatus—should not *in all cases* be saved entire. The trouble involved thereby is not great, and a very little practice will enable the traveling naturalist to save these, the most characteristic bones, even when it is absolutely necessary, as it often is, for him to use the most of every specimen he obtains as food.

Fig. 1.

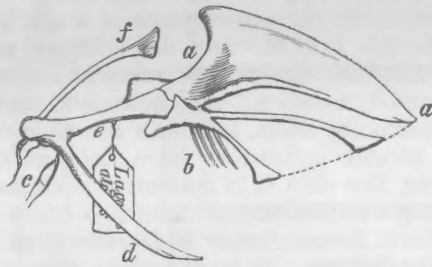
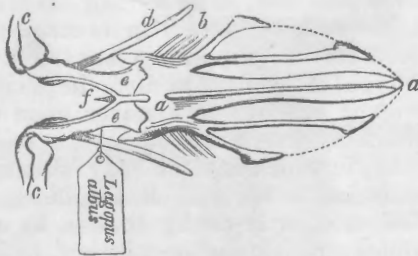


Fig. 2.



The best method of preparing examples of the sternal apparatus or breast bone is as follows: The skin of the bird having been taken off, the operator passes a knife along either side of the keel or ridge of the sternum (*a a*), turning back, as he proceeds, the muscles of the breast, and cutting through the ribs (*b b*) at some little distance from their points of union with the sternum. The wing bones (*c c*) must next be

separated at the joints where they meet the *scapulas*, (*d d*.) the *coracoids*, (*e e*.) and the *furcula* or "merry thought," (*f*.) and as much as is possible of the meat, which is attached to these latter, (the coracoids and furcula,) be removed by the knife. Then laying hold of the still united heads of the coracoids and scapulas with the fingers of one hand, or, if the bird be very small, with a pair of forceps, the scapulas may be drawn out by a steady pull, the flesh which adheres to them being stripped off in the operation by the fingers of the other hand. The forepart of the sternum can now be lifted up, and the few remaining membranes or ligaments which connect it with the body being severed, the whole sternal apparatus—consisting of the *sternum* proper, (*a a*.) the *coracoids*, (*e e*.) the *furcula*, (*f*.) and the *scapulas*, (*d d*)—is easily extracted, and the time occupied by the operation, which it takes so long to describe, will, in the case of a moderately-sized bird, hardly exceed one minute. It then only remains for the collector to rinse or soak the bones for a short time in cold water, for the sake of getting rid of the suffused blood, and to suspend them for a short time exposed to the air; this last part of the process being completed, if the traveler is on the march, by slinging them to the outside of his baggage, whether it be the knapsack he may carry on his back or the pack-saddle of his beast of burden, the simple precaution not being forgotten of keeping them out of the reach of dogs or predatory wild animals, for by neglecting it many are likely to be destroyed.

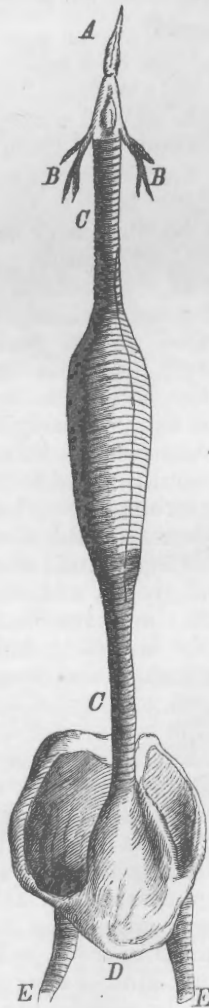
The specimens thus prepared may be packed away in a little dry grass, straw, sea-weed, or paper, there being first of all, affixed to each a ticket with an inscription *corresponding in every respect to that fastened on the skins*, to which they formerly belonged, so that it may be always possible, without chance of mistake, to refer safely the one to the other. These tickets should be tied to one of the coracoid bones, (*e e*.) as always affording the strongest point of attachment.

The removal of the breast bones should always be performed before the carcasses are cooked. If deferred until afterwards, they are almost invariably discolored, rendered greasy, and often warped by that operation; besides which, they run the extra chance of being injured by the carving-knife. Indeed, the dissecting-knife should be employed no more than is absolutely necessary, and then with a light hand and great caution, so as not to cut off any of the sometimes numerous processes which project from the bones, and the situation of which it would be impossible, without a large series of engravings unfitted for a paper of this sort, to bring to the knowledge of traveling naturalists, for whose use it is chiefly intended. It may, however, be remarked that the greatest danger of injury is likely to be incurred in removing the bones of birds of the Gallinaceous order, (*Gallinæ*.) including the turkey, the common fowl, the pheasants, partridges, quails, and grouse, all of which have running along either side of the keel or ridge bone, and only attached to the sternum in front, a long spear-like process, and springing from this again a kind of spur which overlaps the ribs, the interspaces being occupied by membranes. Accordingly, the accompanying illustrations (Figs. 1 and 2) have been chosen from that group, that the collector may be thereby warned of the risk of heedlessly cutting off these appendages. In the Rail tribe, (*Rallidæ*.) also,

these long spear-like processes exist, but without, as far as is known, the lateral spurs.

In many families of birds, as the ducks, (*Anatidæ*), the *trachea* or windpipe of the male, affords valuable means of distinguishing between the different natural groups, or even species, chiefly by the form of the bony labyrinth, *bulba ossea*, situated at or just above the divarication of the bronchial tubes. A little trouble will enable the collector in all cases to preserve this organ perfectly, as represented in the annexed engraving, (Fig. 3.) Before proceeding to skin the specimen, a nar-

Fig. 3.



*Mergus serrator*, ♂.  
Upper surface about one half natural size.

row-bladed knife should be introduced into its mouth, and taking hold of the tongue (A) by the fingers or forceps, the muscles (B B) by which it is attached to the lower jaw should be severed as far as they can be reached, care being of course taken not to puncture the windpipe, (C C;) and, later in the operation of skinning, when dividing the body from the neck or head, not to cut into or through it. This done, the windpipe can be easily withdrawn entire and separated from the neck, and then, the sternal apparatus being removed as before described, its course must be traced to where, after branching off in a fork, (D,) the bronchial tubes (E E) join the lungs. At these latter points it is to be cut off. Then rinsing it in cold water, and leaving it to dry partially, it may, while yet pliant, be either wrapped round the sternum, or coiled up and labelled separately.

By following the above suggestions, it is fully believed that a field naturalist may, with but trifling additional labor, double, or even treble, the scientific value of his ornithological collections, and consequently confer very great benefit on the study which he seeks to promote.

In most cases it will be well to mark the name and number of the specimen with a pen directly on the sternum, especially where the bone is not too greasy to receive the ink. This will obviate any danger arising from an accidental loss of a label.

# NOTES ON THE WINGLESS GRASSHOPPER OF SHASTA AND FALL RIVER VALLEYS, CALIFORNIA,

AND A PLAN FOR KEEPING THEM OUT OF FIELDS.

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BY EDWARD P. VOLLUM, M. D., U. S. A.

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Grasshoppers have infested many parts of California from the earliest days of which there is any record, and they have appeared so regularly and abundantly as to be regarded in some places as an ineradicable plague. The Digger Indians seem to have been long habituated to use them as an article of food, and relish them as much as any kind of subsistence they have. The winged as well as the wingless variety are collected by them for winter use. Both kinds are captured by sinking large pits and firing the grass in a large circle around them. To escape the fire and smoke, the grasshoppers take to the pit, when they are killed by combustibles being thrown upon them. Formerly, the winged grasshoppers were common in Shasta valley; but in the summer of 1856 they gave way to the large wingless kind, which have increased in numbers every year since, till the summer of 1860, when they were more destructive than ever before. During the last three years they have appeared in Fall River valley, but were only in destructive number last summer. They always have their origin in sheltered parts of valleys, where the temperature is higher in winter than the neighboring districts over which they roam in summer. In Shasta valley they breed from or near alkaline flats, where the ground never freezes; and in Fall River valley, they invariably start from the most sheltered part of it. In Shasta valley, after they commence migrating, they always go to the south or southwestward; while in Fall River valley, their course is northward. In both places they leave mountains behind them and traverse a level district; and this seems to be the only cause of the difference of direction pursued by them in the two valleys. In migrating, they are turned aside by mountains. Though they have been in Shasta valley since the summer of 1856, they have been confined to it, and have not crossed any of the mountains which separate it from other valleys. The windings of a river may turn them from their course a little; but if a stream lay across their route, or if embraced in a bend of it, they plunge into the water, in which vast numbers are destroyed,

though a few get over. They can be driven by any rattling noise, and are very timid, alarm spreading rapidly through a considerable host of them; but the fright once over, they invariably return to their original course.

A house is no impediment to them. They do not turn aside, but go over it. They devour all kinds of vegetation, but prefer the cultivated annuals, and do not seem sensitive to poisonous agents; tobacco and stramonium are eaten by them voraciously. A gentleman of Yreka smeared some vegetables with a mixture of strychnia, arsenic, corrosive sublimate, croton oil, and lamp oil, and they devoured them with avidity and perfect impunity. Nor do they seem sensible to pain. If cut in two parts, the head often continues eating; and if legs enough are left, it crawls off readily, and remains active for several hours. The hinder part, severed from the fore part, has been seen to insert the ovipositor into the ground as if to deposit eggs.

Of the many plans devised to keep the *wingless* grasshoppers from fields, the *tin protective* mentioned below is the only one that has been found successful. It was contrived by a gentleman in Shasta valley, where it is generally adopted, and was found to answer the purpose perfectly last summer, when the crops were threatened by greater numbers of grasshoppers than were seen there before.



Fig. 1.

Fig. 1. End view. A board eight or twelve inches wide, closely fitted to the land, is nailed against stakes driven into the ground on the field side. A thin strip of wood or lath is nailed on the upper edge of the board, about three inches wide at least, and about a quarter of an inch thick. A strip of tin or zinc, two and a half inches wide is next tacked against the outer edge of the lath.

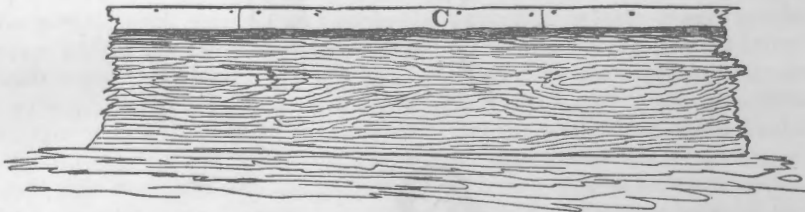


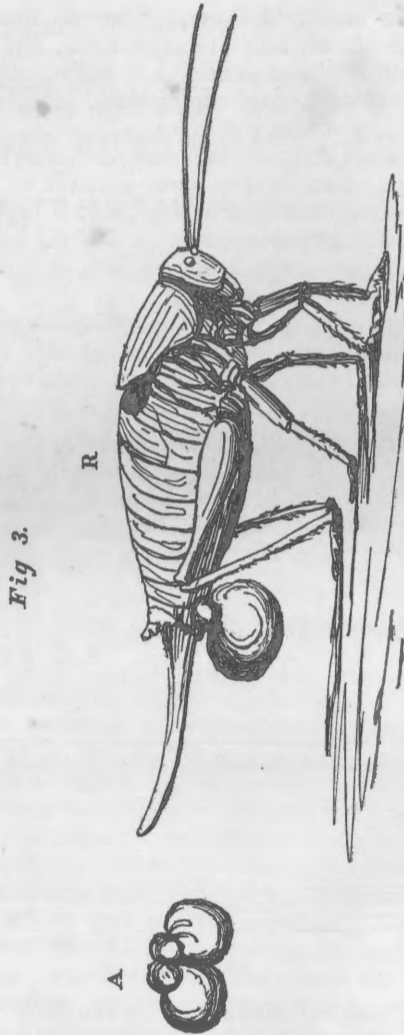
Fig. 2.

Fig. 2. Side view, looking outwards from the field. C is the strip of tin, two and a half inches wide, tacked against the lath, which is nailed on top of the board, eight or twelve inches wide. A little earth is generally heaped against the board on the side looking from the field, to prevent the grasshoppers from creeping under where the inequalities or looseness of the ground would favor them.

The operation of the tin protective consists in the inability of the grasshopper to reach from the under surface of the lath, Fig. 1, around the edge of the tin to the upper surface of the lath, which would be necessary to enable it to get on the top of the protective and enter the field. The strip of tin should not be less than two and a half

NOTES ON THE WINGLESS GRASSHOPPER.

inches for the kind of grasshopper the protective was contrived against. (See Fig. 3.\*) Two inches, and other measurements, have been effectually tried; but the above width accomplishes the object with certainty,



if the protective is made with ordinary care. Of course, any width of tin over two and a half inches is secure; but this is the minimum that will answer against the ordinary California wingless grasshopper. The lath and tin fixed to the top of a board fence, or the tin alone made three inches wide and tacked horizontally on the top of the fence, answers completely. The most approved way for farms is to place the contrivance (Fig. 1) inside the fence, and disconnected therefrom.

\* In this figure A represents the egg bag.



When the grasshoppers climb over buildings, or up trees, to reach a garden, a strip of tin tacked horizontally around the building or tree, and of sufficient width, and at any distance from the ground, will form a protection against them.

Where tin cannot be procured, and the soil is crumbly, the following plan will succeed, in a great measure, in preventing the grasshopper from entering fields, and at the same time occasion the destruction of great numbers of them, viz: Dig a ditch around the field about eighteen inches wide and two feet deep, shelving inwards towards the field, from the upper inside edge to the bottom, and sink holes in the bottom of the ditch about two feet deep, and at intervals of every few yards. The grasshoppers get into the ditch in endeavoring to enter the field, and fail, on account of its crumbling condition, to ascend the inside inclined surface, and eventually collect in great numbers in the holes in the bottom of the ditch and die. If there are roots in the soil, this plan will not answer, as they readily climb up these, and thus get out of the ditch. Many enter the fields notwithstanding this obstacle, but bushels of them collect in the ditch and holes in the bottom, where they can easily be destroyed by rammers and paddles, though the majority that get in the holes die from the pressure of the superincumbent mass. This plan, though greatly inferior to the *tin protective*, will save most of a crop, and can be readily employed in some localities, and when materials for the other cannot be procured, a ditch of swift running water also affords a good protection, though many cross it.

FORT CROOK, CALIFORNIA, *November*, 1860.

LETTER RELATIVE TO THE OBTAINING OF SPECIMENS  
OF FLAMINGOES AND OTHER BIRDS FROM SOUTH  
FLORIDA.

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BY THE LATE GUSTAVUS WURDEMAN.

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INDIAN KEY, FLORIDA,  
August 27, 1857.

SIR: It gives me pleasure to be able to inform you that I have lately been quite successful in my researches as it regards the science of ornithology. Many specimens have been procured, and if I have added one item of interest or of what is useful to science I shall consider myself well paid for the labor.

At the Tortugas are two keys or islands, East Key and Bird Key, which serve as places of resort to the noddies and laying gulls to deposit their eggs and raise their young. They are watched closely at East Key by boatmen, who gather the eggs to carry them to Key West for sale. But at Bird Key the birds are under the special protection of Captain D. P. Woodbury, the officer in charge of construction of the fortifications. I am indebted to the courtesy of this gentleman for a visit to the latter Key to procure birds for the Smithsonian Institution. Upon our approaching the island we were met by the male birds, protesting against our landing. The keys are covered with Bay cedar bushes seven or eight feet in height, interspersed here and there with the cactus, among which some young laying gulls sought refuge. Their eggs are laid on the sand, whilst the noddies lay in nests built from two to six feet from the ground of dried sticks or twigs. Only one egg was found in each noddie's nest, and about two in the laying gull's. Their eggs were said to have been taken some time previous to our visit, and that they lay usually two and three. I picked up several female laying gulls with my hands, and might have caught noddies if I had not been encumbered with the gun, birds, and eggs. No young noddies were seen at this time, which was the last week of June.

Large numbers of men-of-war hawks congregate there, and it is said for no good purpose; they are accused of robbing the gulls of fish and of their eggs, and even of devouring their young, which charges I think are not all well founded. I examined the stomach of a female bird killed by Captain Woodbury, and found it contained a middle sized mullet and a full grown flying fish. Upon my paying a second visit to the same key to get a *nest* I started at least fifty men-of-war hawks,

among which was not a single male bird. I killed a black parakeet, which is the third specimen seen at the Tortugas. It has also been seen at Key West during the last fifteen years.

Having shot a Florida wild pigeon (white headed) at the same place, and learning that they were numerous on the keys to the eastward, I felt a great desire to learn something more about them. Upon my return to this island, Captain William H. Bethel, in charge of this key, informed me that they breed on the neighboring keys, and that he, in company with another man, had killed nearly two hundred in a day on an island not larger than an acre in area. July 23 we visited two small keys six miles to northwest from here, one of which is inundated at high water, and the other nearly so. Upon going on shore, Captain Bethel called the pigeons, (*kroo-ko-ko*, laying the accent upon the last syllable,) to which they answered in the same notes, some flying towards us. We killed eighteen. The eggs were nearly hatched, and would not blow, except two or three which I send in a tin canister. Two will also be found in alcohol. Their nests are built of dried sticks in the mangroves between high and low water mark on the east side, to get the benefit of the sea-breezes, and because the mosquitoes are less numerous there. One nest was found near the middle of the key. They lay two white eggs, rounded on each end. The craws of the males were full of a kind of red oval berry, which grows on the larger and dry islands, whilst those of the females were empty. The birds were very shy, so that it was difficult to approach near enough to shoot them.

A number of Indian pullets were killed here lately, of which I succeeded in securing two. One was shot by a soldier from a cocoanut tree, and the other by myself. The last one had hid himself upon the ground among some bushes, and flew short distances when he was started, emitting at the same time a single low note. His gizzard contained a fine, dark green, and dry vegetable matter. Nothing is known of these birds. They are frequently met with at sea, and will light on board of vessels to rest themselves, and are found here at every season of the year.

The flamingo is known to but a very few inhabitants of this State, because it is confined to the immediate neighborhood of the most southern portion of the peninsula, Cape Sable, and the keys in its vicinity. It was seen by the first settlers at Indian river, but abandoned these regions immediately, and never returned thither after having been fired upon. It goes northward as far as Cape Romano, on the west coast of Florida. It is seen in these localities at every season of the year, but it is not known where it breeds. It is supposed to build its nests in the fresh-water lakes near Cape Sable, and is said to set on its eggs whilst standing upon its feet; the great length of its legs not permitting it to rise with the same facilities as other aquatic birds.

I had never seen any of these birds, and having been told they may be caught during the latter part of June and beginning of July, when moulting, and that wreckers had obtained a large number of them, I felt a great anxiety to go on an expedition to capture them; but how was this to be accomplished? Was it to be left to destiny? I had no boat at my command, nor could any be hired, as everybody was afraid to visit the

regions the birds inhabited on account of the Indians. July was passing away, and although I frequently turned my conversation upon flamingoes to sound the people, no one offered to go except a wrecker, and when the time arrived, he had to leave for Key West; and I thought that with him vanished my last hope of accomplishing my object. But this was not so. About the 4th of August, a black man arrived in a small boat, and told me he was going to catch flamingoes to carry them to Key West for sale, where he could obtain for them four or five dollars a pair. He was persuaded to wait a day in order that he might have a larger boat and a white man to accompany him. He was half Seminole and half negro; but I had to look upon him as the captain, as he was very skillful in the management of a boat, and intimately acquainted with the channels. We started in a schooner, taking a canoe in tow in which to chase the flamingoes. We soon lost sight of Indian Key, to the southeast, and after having sailed about three miles beyond, reached the head of the channel. The boat could go no further; so, after coming to anchor, we took to the canoe and paddled onward among the countless islands, all thickly overgrown with trees. We passed one where General Harney captured and hung some of the Indians that burned the Key seventeen years ago. All seemed still. There was no sign of human life, and only here and there a solitary crane walking under the thick mangroves, or a pigeon or black bird crossing from key to key. No other kind of animation was seen. I began to suspect that the absence of the birds indicated the presence of the Indians, and looked around for their canoes to give us chase.

After awhile, the captain shouted "The flamingoes! the flamingoes!" but I could see nothing until we had advanced another mile, when I noticed two red spots apparently under two distant keys, which proved to be large flocks of these birds. They started when we came within half a mile, leaving six of their number behind them, which our captain said were moulting, and would soon be his property. Paddling as fast as we could, we soon came up with the birds, which employed both legs and wings to escape us. The captain, however, seized one after another and flung them into the boat, where I held them fast by their legs until they could be tied. We thus captured the six, and rejoicing in our success, followed the principal flock, but found they could all fly. Hoisting sail, we stood to the northward, going tolerably fast, and had sailed about two miles when we discovered large numbers of flamingoes to the northwest, distant about a mile and a half. The canoe being headed for them, it was some time before we could see that a large number were flapping their wings upon the surface of the water, propelling themselves as fast as they could to escape from us, whilst others, depending upon the strength of their wings for safety, stood still, but started long before we came within rifle shot, and lighted at a more distant place.

It was some time before we appeared to gain on the fugitives, and as we were out of sight of our big boat, I was not very anxious to continue the chase; but the captain, anxious to make the most of the expedition, urged going on; until passing a flock of several dozen, a number were caught and thrown into the canoe, where I packed

them up as well as I could. Presently we came up to the main body, which amounted to about one hundred birds, all closely huddled together, so that two discharges of my gun would probably have left none of them alive. The captain seized two and three of them at a time, and when I remarked that our boat was filled, he suddenly jumped overboard on top of the flamingoes, embracing a number with his arms at once, whilst the rest were allowed to depart in peace. Having tied their legs, they were thrown upon the others, forward, amidship, and aft, to keep them down. Thus were more than a hundred of these unfortunate birds packed away in the little canoe, without regard to their comfort or their lives. We were so laden down that the sail could not be used. I had to sit upon the center-board, resting my feet on the gunwale to avoid injuring the birds, which were struggling, flapping their wings, and covering everything with their blood; scarcely one of them escaped injury. The boat had to be shoved back to where we left the other at anchor, arriving there about sunset. Many of the birds had died, and some were drowned in the bottom of the canoe, which began to fill.

Considering myself a passenger, I laid no claim to what we had captured, but offered twelve and a half cents for every dead bird I should skin. This was accepted. Picking out some of the cleanest ones, I skinned them on the way home, knowing they could not keep till the next day. The birds were very fat, and being without cotton, their plumage was very much soiled with blood, which I hope can be removed. Arriving home, the live birds were confined in a ten-pin alley, and the dead distributed among the soldiers, wreckers, and others.

There were not less than five hundred flamingoes assembled where the last were taken. We must have been close to the main land, which was shut out of our view by the numerous keys.

The flamingoes congregate in the shallow waters before mentioned. Their food consists of a small shell fish of the form of a clam, which they fish up from the muddy banks, no other kind of food being found in their craws. They are always seen in flocks, and their notes sound at a distance like those of wild geese; but when captured, they emit a low single note like a crane when suddenly started. Whilst in confinement one of them hollowed like a domestic goose when calling for its mate, which was answered by another bird in notes similar to those of a gander, so that from their cries one would have supposed them to be a flock of domestic geese, instead of flamingoes.

They were fed on rice and fresh water while they were prisoners, but declined to touch it as long as they were watched.

Of eight birds which I had an opportunity to examine, only one proved to be a female. This bird's neck came off while I was preparing it, but still I shall send it as it is. The black feathers under her wings being large, it is probable that the females moult before the males. It seems almost as if nature had not done this bird full justice in not giving it the means to protect itself while shedding its feathers, as it then falls an easy prey to its enemies, which must eventually lead to its extermination.

It required the greatest care to prevent the insects from destroying

the feathers ; and being obliged to skin the birds in a hurry, I was careless with the arsenic, which threatened at one time to deprive me of my finger nails. You will receive six flamingoes, which will be sent in the early part of next winter, with other birds and specimens. A wrecker informs me that a flamingo has become perfectly tame on board his vessel, and will take the food from his hands. Our success encouraged others to start on an expedition after flamingoes, but they returned without having been able to find the channel.

[The flamingo is found in great numbers on the Bahama Islands. Mr. J. L. Hurdis states that a party from Bermuda, in July, 1850, caught a number. The following account was given by one of the party: "They visited Lake Rosa at a distance of fifteen miles from the port where the vessel lay, and waded to some of the islands which dotted its surface, the water being only knee deep. On one of these islands they disturbed a large number of flamingoes, at least two hundred, which were too shy to admit of a near approach, and were all in red plumage. These would settle on some distant margin of the lake in line 'resembling a company of soldiers.' On reaching the rocky shore of the island in question, many young flamingoes were discovered, some of which were run down and captured. They had an awkward gait, but scuttled along at a good pace. These were in the gray plumage, and of different stages of growth, the larger just putting forth the quill feathers of the wings. Hollis confidently states that he saw upwards of a thousand old flamingoes on the lake that day, or rather on the small portion of it visited by him. He also saw many nests of these birds, and found several of their eggs, which appeared to have been thrown out by the parent birds, and proved to be addled. They were white and about the size of a common goose egg. The nests were composed of mud and sticks more or less raised, on account of surrounding water; the highest of these were certainly not more than nine inches from the ground, while many others were nearly level with it. The surface was hollowed out, and capable of holding about two eggs; not more. I referred to Wilson's "American Ornithology," and read the paragraph which describes the elevated nest constructed by this bird to admit of its long legs dangling on each side during the duties of incubation. At this my informant smiled, and assured me that he had seen nothing of the kind; that he had particularly noticed many of their nests, and that in no one instance did the height of any of them exceed what he had already stated."]

A few warblers, and a large number of house and barn swallows, made their appearance here during the last two weeks. The latter are only seen flying, and never alight.

The mourning doves and king birds were the only birds that spent the summer on this key.

I shall soon go to Cape Florida, and, if nothing happens, collect all the birds to be met with in that region.

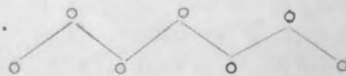
NOTE.—The birds referred to by Mr. Wurdeman will be found described in the ninth volume of the Pacific Railroad Reports, as follows: Noddy, (*Anous stolidus*;) Laying Gull, (*Sterna fuliginosa*;) Black Parrakeet, (*Crotophaga rugirostris*;) Flamingo, (*Phoenicopterus ruber*;) Man-of-war Hawk, (*Tachypetes aquila*;) Wild Pigeon, (*Columba leucocephala*;) Indian Pullet, (*Aramus giganteus*.)

## ON THE HABITS OF THE POUCHED RAT, OR SALAMANDER, (*GEOMYS PINETI*), OF GEORGIA.

BY WM. GESNER, M. D., OF COLUMBUS, GA.

On the 29th of last March, with my friend, Mr. L. C. Allen, and our negro man, we moved our camp into the piny woods, among the salamander hills, in Russel county, Alabama, about seven miles from Columbus. We expected at this time to find the salamanders breeding, and went prepared with spades, hoes, &c., for the purpose of digging them out.

Having found a pair at work on an eligible spot for digging, we commenced on their trail at the newest mound, and followed their hole, which pursued a course along the line of junction between the soil and subsoil, where the roots abound most, at an average depth from the surface of twelve inches, for a distance of twenty yards. The mounds along this subterranean chamber were at intervals of about three feet, with little variation, and angling as was the chamber thus. The passage leading to each old mound was plugged up perfectly solid, and so were they all, except the newest one, in which the animals were working just before they were attacked, and which was at the time quite small.



Chamber and mounds.

At the distance of twenty yards, the gallery forked in two directions; one followed a chain of mounds up and along the brow of the hillock. These mounds were old, and the average distance apart. The other took the direction toward a large pine, around whose roots the mounds were thick and in clusters, from which we inferred deep digging and their nest.

We followed the hole, which widens and narrows in its course towards the pine, as if for turnouts; reaching the pine the hole took a spiral direction downwards to the depth of five feet, and rose again spirally to three, where we found an oblong cavity scooped out, of the capacity of a peck measure or more, filled with very fine dry grass, and yet warm in the two impressions, which were similar to those in a squirrel's nest, where the animals had been in it, no doubt, while we were coming upon them. They had left, however, and there were no young ones.

A little way from the nest was another cavity, of the capacity of a pint measure, partly filled with roots of the wild potato and nuts of the pig grass. A hole about eighteen inches deep, still further on,

which sloped at an angle of about  $45^{\circ}$ , was nearly full of the animal's manure, and, strange to say, we found no dung anywhere else in the run.

After spending the day in following these animals through all their chambers, which involved digging to the distance of from three to four hundred yards, we gave them up at a place where the hole was still open, but the mounds almost entirely obliterated and overgrown with grass.

We had either thrown the animals out with the loose dirt, having doubled themselves up and remained quiet, so as to escape our observation, which was very close, or dug obliquely away from us, and plugged the hole after them in such a manner that we could not see it. Ordinarily it is as easy to follow the plug as the hole, for the sand in which they work here is tinted of so many colors that the plug can be easily recognized.

They were at work the following morning near the pine tree, in the ditch, and among the loose earth we had made; but although we attacked them again, they eluded us.

This day we dug out another pair, correcting and substantiating our former observations, by their works, which differed in no important point from the first. I have had these two pairs dug out, one of them once, and the other twice, each time taking away a nest and store of provisions, and they are still unhurt, and working away in the same place. They work in raising their mounds, at which time they are tunneling and collecting their food, mostly from four o'clock in the morning until ten. The work is performed very rapidly, and from two to five mounds the general average, and a distance accomplished of from nine to fifteen feet; but where they strike a place sparse of food, they do not limit themselves to the morning for their season of labor, or to any number of mounds, working, as I have witnessed all day, if necessary. They stop work frequently for weeks at a time, and no doubt live on the store in their dens. They are very fond of sweet potatoes, and when they enter the patches of that vegetable, grown by the poor people of this region, commit great and unrestrained havoc; for to their inexperience in catching them, may be added a superstitious dread that it is sure death to see one of them; consequently these people are not to be relied on to furnish specimens.

In the plowed earth of a potato field, they are not particular with their mounds, but displace the earth more after the manner of moles.

The instinct inducing them to rise to the surface every three feet, or thereabouts, to find a new deposit for the earth, which must be carried out, to be displaced, on account of the depth at which they work and the size of their bodies, is only equalled by the sagacity of the angular direction of their tunnels, which is calculated to intercept the roots of a greater amount of surface growth than a direct course would.

In working, they collect a lot of the loose earth in the bottom of the almost perpendicular hole leading to the surface, and then push it before them out over the edges, exposing their bodies but very little in the act, and retiring immediately backwards.

The most they expose themselves is in collecting dry grass for their nests, and that is but for a moment at a time. They select only high



and dry situations for their dwellings, from which the water will flow off easily; and it is my opinion that for drink they subsist entirely on the juices of the roots they eat. I hope, in your anatomical examinations, you will hold this probability in mind. There is no doubt but water and snakes are their greatest enemies, and that they plug their holes leading to the surface as well against one as the other.

The one last sent you I had alive, and think I killed him by pouring drops of water on his nose, which he took very ungraciously. Also, when I opened him, I found water diffused between the coats of the stomach.

He was cut off with a long-bladed spade while throwing out a load of earth, and taken alive. As for trapping, I have had them cover up the trap, bait, and all, with their mounds, too often to expect anything from that process.

A CATALOGUE OF THE BIRDS OF CHESTER COUNTY, PENNSYLVANIA, WITH THEIR TIMES OF ARRIVAL IN SPRING, FROM OBSERVATIONS ANNUALLY FOR TEN SUCCESSIVE YEARS.

BY VINCENT BARNARD.

1. *Cathartes aura*, Illig.—Turkey Buzzard. Common.
2. *Falco anatum*, Bonap.—Duck Hawk. Very rare.
3. *Falco columbarius*, Linn.—Pigeon Hawk. Not common.
4. *Falco sparverius*, Linn.—Sparrow Hawk. Common resident.
5. *Astur atricapillus*, Bonap.—Goshawk. Very rare.
6. *Accipiter cooperi*, Bonap.—Cooper's Hawk. Frequent.
7. *Accipiter fuscus*, Bon.—Sharp-shinned Hawk. Frequent resident.
8. *Buteo borealis*, Vieill.—Red-tailed Hawk. Common resident.
9. *Buteo lineatus*, Jardine—Red-shouldered Hawk. Frequent resident.
10. *Archibuteo lagopus*, Gray—Rough-legged Hawk. Uncommon.
11. *Ictinia mississippiensis*, Gray—Mississippi Kite. Very rare.
12. *Aquila canadensis*, Cassin—Golden Eagle. Rare.
13. *Haliaeetus leucocephalus*, Savigny—Bald Eagle. Frequent.
14. *Pandion carolinensis*, Bon.—Fish Hawk. Not uncommon.
15. *Strix pratincola*, Bonap.—Barn Owl. Of rare occurrence.
16. *Bubo virginianus*, Bon.—Great Horned Owl. Frequent resident.
17. *Scops asio*, Bonap.—Mottled Owl. Common resident.
18. *Otus wilsonianus*, Lesson—Long-eared Owl. Frequent.
19. *Brachyotus cassinii*, Brewer—Short-eared Owl. Frequent.
20. *Syrnium nebulosum*, Gray—Barred Owl. Frequent.
21. *Coccygus americanus*, Bonap.—Yellow-billed Cuckoo. April 25 to May 5.
22. *Coccygus erythrophthalmus*, Bon.—Black-billed Cuckoo. May 5 to 10.
23. *Picus villosus*, Linn.—Hairy Woodpecker. Frequent resident.
24. *Picus pubescens*, Linn.—Downy Woodpecker. Common resident.
25. *Sphyrapicus varius*, Baird—Yellow-bellied Woodpecker. Frequent resident.
26. *Hylotomus pileatus*, Baird—Black Woodcock. Very rare.
27. *Centurus carolinus*, Bon.—Red-bellied Woodpecker. Not common resident.
28. *Melanerpes erythrocephalus*, Sw.—Red-headed Woodpecker. April 27 to May 1.
29. *Colaptes auratus*, Sw.—Flicker. March 21 to 30.

30. *Trochilus colubris*, Linn.—Ruby-throated Humming Bird. April 23 to May 1.
31. *Chætura pelagica*, Steph.—Chimney Swallow. April 15 to 18.
32. *Antrostomus vociferus*, Bonap.—Whip-poor-will. April 26 to May 2.
33. *Chordeiles popetue*, Baird—Night Hawk. April 28 to May 6.
34. *Ceryle alcyon*, Boie.—Belted Kingfisher. March 25 to April 10.
35. *Tyrannus carolinensis*, Baird—King Bird. April 26 to 30.
36. *Myiarchus crinitus*, Cab.—Great Crested Flycatcher. April 28 to May 5.
37. *Sayornis fuscus*, Baird—Pewee. March 2 to 15.
38. *Contopus virens*, Cab.—Wood Pewee. April 26 to 30.
39. *Empidonax minimus*, Baird—Least Flycatcher. May 10 to 15.
40. *Empidonax acadicus*, Baird—Small Green-crested Flycatcher. May 5 to 12.
41. *Empidonax flaviventris*, Baird—Yellow-bellied Flycatcher. May 8 to 14.
42. *Turdus mustelinus*, Gm.—Wood Thrush. April 11 to 25.
43. *Turdus pallasi*, Cab.—Hermit Thrush. April 28 to May 5.
44. *Turdus fuscescens*, Stephens—Wilson's Thrush. April 15 to 30.
45. *Turdus swainsonii*, Cab.—Olive-backed Thrush. April 25 to May 4.
46. *Turdus migratorius*, Linn.—Robin. Resident.
47. *Sialia sialis*, Baird.—Blue Bird. Almost resident.
48. *Regulus calendula*, Licht.—Ruby-crowned Wren. April 6 to 22.
49. *Regulus satrapa*, Licht.—Golden-crested Wren. April 5 to 22.
50. *Anthus ludovicianus*, Licht.—Titlark. March 2 to 10.
51. *Mniotilta varia*, Vieill.—Black and White Creeper. April 25 to May 2.
52. *Parula americana*, Bonap.—Blue Yellow-backed Warbler. May 2 to 12.
53. *Protonotaria citrea*, Baird—Prothonotary Warbler. Rare.
54. *Geothlypis trichas*, Cab.—Maryland Yellow-Throat. May 5 to 15.
55. *Geothlypis tephrocotis*, Cab.—Michener's Warbler. Rare.
56. *Oporornis agilis*, Baird—Connecticut Warbler. Not common.
57. *Oporornis formosus*, Baird—Kentucky Warbler. May 12 to 20.
58. *Icteria viridis*, Bonap.—Yellow-breasted Chat. May 4 to 13.
59. *Helmitherus vermivorus*, Bonap.—Worm-eating Warbler. May 6 to 15.
60. *Helminthophaga pinus*, Baird—Blue-winged Yellow Warbler. May 1 to 8.
61. *Helminthophaga chrysoptera*, Baird—Golden-winged Warbler. May 4 to 18.
62. *Helminthophaga ruficapilla*, Baird—Nashville Warbler. May 3 to 10.
63. *Helminthophaga peregrina*, Cab.—Tennessee Warbler. May 20 to 25.
64. *Seiurus aurocapillus*, Sw.—Golden-crowned Thrush. April 21 to 27.
65. *Seiurus noveboracensis*, Nutt.—Water Thrush. April 25 to 30.
66. *Seiurus ludovicianus*, Bon.—Large-billed Water Thrush. April 25 to May 5.

67. *Dendroica virens*, Baird—Black-throated Green Warbler. May 5 to 10.
68. *Dendroica canadensis*, Baird—Black-throated Blue Warbler. May 15 to 20.
69. *Dendroica coronata*, Gray—Yellow Rump. April 21 to 26.
70. *Dendroica blackburniæ*, Baird—Blackburnian Warbler. May 10 to 15.
71. *Dendroica castanea*, Baird—Bay-breasted Warbler. May 20 to 26.
72. *Dendroica pinus*, Baird—Pine Creeping Warbler. May 12 to 20.
73. *Dendroica pennsylvanica*, Baird—Chestnut-sided Warbler. May 8 to 12.
74. *Dendroica caerulea*, Baird—Blue Warbler. May 6 to 10.
75. *Dendroica striata*, Baird—Black-poll Warbler. May 20 to 25.
76. *Dendroica æstiva*, Baird—Yellow Warbler. May 1 to 5.
77. *Dendroica maculosa*, Baird—Black and Yellow Warbler. May 5 to 8.
78. *Dendroica tigrina*, Baird—Cape May Warbler. May 6 to 10.
79. *Dendroica palmarum*, Baird—Yellow Red Poll. April 20 to 25.
80. *Dendroica discolor*, Baird—Prairie Warbler. May 8 to 15.
81. *Myiodioctes mitratus*, Aud.—Hooded Warbler. May 10 to 15.
82. *Myiodioctes pusillus*, Bon.—Green Black-cap Flycatcher. May 5 to 12.
83. *Myiodioctes canadensis*, Aud.—Canada Flycatcher. May 4 to 10.
84. *Setophaga ruticilla*, Sw.—Redstart. May 5 to 10.
85. *Pyrranga rubra*, Vieill.—Scarlet Tanager. April 27 to 30.
86. *Pyrranga æstiva*, Vieillot—Summer Red Bird. Very rare.
87. *Hirundo horreorum*, Barton—Barn Swallow. April 15 to 25.
88. *Hirundo lunifrons*, Say—Cliff Swallow. April 25 to May 5.
89. *Hirundo bicolor*, Vieill.—White-bellied Swallow. April 16 to 28.
90. *Cotyle riparia*, Boie—Bank Swallow. April 25 to May 2.
91. *Cotyle serripennis*, Bon.—Rough-winged Swallow. April 28 to May 5.
92. *Progne purpurea*, Boie—Purple Martin. April 1 to 10.
93. *Ampelis cedrorum*, Baird—Cedar Bird. May 10 to 15.
94. *Collyrio borealis*, Baird—Great Northern Shrike. Winter resident; rare.
95. *Vireo olivaceus*, Vieill.—Red-eyed Flycatcher. April 25 to May 1.
96. *Vireo gilvus*, Bon.—Warbling Flycatcher. April 25 to 30.
97. *Vireo noveboracensis*, Bon.—White-eyed Vireo. May 1 to 4.
98. *Vireo solitarius*, Vieill.—Blue-headed Flycatcher. May 2 to 8.
99. *Vireo flavifrons*, Vieill.—Yellow-throated Flycatcher. May 2 to 10.
100. *Mimus polyglottus*, Boie—Mocking Bird. Very rare.
101. *Mimus carolinensis*, Gray—Cat Bird. April 28 to May 6.
102. *Harporhynchus rufus*, Cab.—Brown Thrush. April 25 to 29.
103. *Thriothorus ludovicianus*, Bon.—Great Carolina Wren. Resident.
104. *Thriothorus bewickii*, Bon.—Bewick's Wren. Very rare.
105. *Cistothorus stellaris*, Cab.—Short-billed Marsh Wren. Very rare.

106. *Troglodytes ædon*, Vrèill.—House Wren. April 20 to 26.
107. *Troglodytes hyemalis*, Vrèill.—Winter Wren. November 20 to 30.
108. *Certhia americana*, Bonap.—American Creeper. Resident.
109. *Sitta carolinensis*, Gm.—White-bellied Nuthatch. Resident.
110. *Sitta canadensis*, Linn.—Red-bellied Nuthatch. Resident.
111. *Polioptila cærulea*, Sclat.—Blue Gray Fly-catcher. April 15 to 25.
112. *Lophophanes bicolor*, Bon.—Fufted Titmouse. Resident.
113. *Parus atricapillus*, Linn.—Black-cap Titmouse. Resident.
114. *Parus carolinensis*, Aud.—Carolina Titmouse. Resident.
115. *Eremophila cornuta*, Boie.—Sky Lark. December 5 to 22.
116. *Carpodacus purpureus*, Gray—Purple Finch. October 30 to November 10.
117. *Chrysomitris tristis*, Bon.—Yellow Bird. Resident.
118. *Chrysomitris pinus*, Bon.—Pine Finch. Rare in winter.
119. *Curvirostra leucoptera*, Wils.—White-winged Crossbill. December, 1854, rare.
120. *Ægiothus linaria*, Cab.—Lesser Red-Poll. Very rare in winter.
121. *Plectrophanes nivalis*, Meyer—Snow Bunting. Rare in winter.
122. *Passerculus savanna*, Bon.—Savannah Sparrow. May 1 to 6.
123. *Poocetes gramineus*, Baird—Grass Finch. Often resident.
124. *Coturniculus passerinus*, Bon.—Yellow-winged Sparrow. April 22 to 26.
125. *Coturniculus henslowi*, Bon.—Henslow's bunting. Seldom found.
126. *Zonotrichia leucophrys*, Sw.—White-crowned Sparrow. May 10 to 20.
127. *Zonotrichia albicollis*, Bon.—White-throated Sparrow. November 22 to 30.
128. *Junco hyemalis*, Sclat.—Snow Bird. October 18 to 27.
129. *Spizella monticola*, Baird—Tree Sparrow. October 15 to 20.
130. *Spizella pusilla*, Bon.—Field Sparrow. March 26 to 31.
131. *Spizella socialis*, Bon.—Chipping Sparrow. April 3 to 10.
132. *Melospiza melodia*, Baird—Song Sparrow. Resident.
133. *Melospiza palustris*, Baird—Swamp Sparrow. April 26 to 30.
134. *Passerella iliaca*, Sw.—Fox-colored Sparrow. November 18 to 24.
135. *Euspiza americana*, Bon.—Black-throated Bunting. April 27 to May 3.
136. *Euspiza townsendii*, Bon.—Townsend's Bunting. But one specimen known.
137. *Guiraca ludoviciana*, Sw.—Rose-breasted Grosbeak. May 10 to 16.
138. *Cyanospiza cyanea*, Baird—Indigo Bird. April 28 to May 4.
139. *Cardinalis virginianus*, Bonaparte—Red Bird. Resident.
140. *Pipilo erythrophthalmus*, Vieill.—Ground Robin. April 21 to 27.
141. *Dolichonyx oryzivorus*, Sw.—Boblink. May 4 to 7.
142. *Molothrus pecoris*, Sw.—Cow Bird. March 9 to April 1.
143. *Agelaius phœniceus*, Vrèill.—Swamp Blackbird. March 6 to 12.
144. *Sturnella magna*, Sw.—Meadow Lark. Resident.
145. *Icterus spurius*, Bon.—Orchard Oriole. April 25 to 28.
146. *Icterus baltimore*, Daudin—Baltimore Oriole. April 26 to 28.
147. *Scolecophagus ferrugineus*, Sw.—Rusty Blackbird. March 20 to 26.

148. *Quiscalus versicolor*, Vieill.—Crow Blackbird. March 5 to 10.
149. *Corvus carnivorus*, Bartram—American Raven. Very rare.
150. *Corvus americanus*, Aud.—Common Crow. Resident.
151. *Corvus ossifragus*, Wilson—Fish Crow. Not common.
152. *Cyanura cristata*, Sw.—Blue Jay. Resident.
153. *Ectopistes migratoria*, Sw.—Wild Pigeon. Very irregular.
154. *Zenaidura carolinensis*, Bon.—Common Dove. March 10 to 22.
155. *Meloeagris gallopavo*, Linn.—Wild Turkey.
156. *Bonasa umbellus*, Steph.—Ruffed Grouse. Resident.
157. *Ortyx virginianus*, Bon.—Partridge, Quail. Resident.
158. *Grus americanus*, Ord.—Whooping Crane. Not common.
159. *Herodias egretta*, Gray—White Heron. Seldom found.
160. *Ardea herodias*, Linn.—Great Blue Heron. Irregular occurrence.
161. *Botaurus lentiginosus*, Steph.—Bittern. Rather rare.
162. *Butorides virescens*, Bon.—Green Heron. March 24 to 31.
163. *Nyctiardea gardeni*, Baird—Night Heron. Rare.
164. *Charadrius virginicus*, Borck.—Golden Plover. Very rare, autumn.
165. *Ægialitis vociferus*, Cassin—Killdear. Almost resident.
166. *Squatarola helvetica*, Cul.—Black-bellied Plover. Rare.
167. *Philohela minor*, Gray—American Woodcock. March 10 to 18.
168. *Gallinago wilsonii*, Bon.—English Snipe. March 8 to 12.
169. *Gambetta melanoleuca*, Bon.—Tell-tale, Stone Snipe. Scarce.
170. *Gambetta flavipes*, Bon.—Yellow Legs. Not common.
171. *Rhyacophilus solitarius*, Bon.—Solitary Sandpiper. April 27 to May 2.
172. *Tringoides macularius*, Gray—Spotted Sandpiper. April 20 to 26.
173. *Actiturus bartramius*, Bon.—Field Plover. April 21 to 29.
174. *Porzana carolina*, Vieill.—Common Rail. Not common.
175. *Fulica americana*, Gmelin—Coot. Irregular occurrence.
176. *Gallinula galeata*, Bon.—Florida Gallinule. Accidental.
177. *Bernicla canadensis*, Boie—Canada Goose. Pass county in early May and November.
178. *Anas obscura*, Gm.—Black Duck. Rare.
179. *Spatula clypeata*, Boie—Shoveller. Rare.
180. *Aix sponsa*, Boie—Summer Duck. Frequent.
181. *Fulix affinis*, Baird—Little Black-head. Rare.
182. *Bucephala albeola*, Baird—Butter Ball. Not common.
183. *Erismatura rubida*, Bon.—Ruddy Duck. Rare.
184. *Mergus americanus*, Cass—Sheldrake. Not common.
185. *Lophodytes cucullatus*, Reich.—Hooded Merganser. Frequent.
186. *Chroicocephalus philadelphia*, Lawrence—Bonaparte's Gull. Very rare.
187. *Sterna fuliginosa*, Gmelin—The Sooty Tern. Very rare.
188. *Colymbus torquatus*, Brunnich—Loon; Northern Diver. Not common.
189. *Podiceps griseigena*, Gray—Red-necked Grebe. Rare.
190. *Podiceps cornutus*, Latham—Horned Grebe. Rare.
191. *Podilymbus podiceps*, Lawrence—Pied-bill Grebe. Not common.

# ON THE FORESTS AND TREES OF FLORIDA AND THE MEXICAN BOUNDARY.\*

BY J. G. COOPER, M. D.

During an exploration of East Florida, from Key West north, made between March 6th and June 10th, 1859, the writer was enabled to make the following additions to the Sylva of the United States, as well as new observations on their range, &c.:

No., &c.	Botanical name.	Popular name.	Height.	Range.
3 <i>b</i>	ANONA, <i>Linn.</i> <i>laurifolia, Dunal</i> .....	CUSTARD APPLE.	30	Biscayne Bay.
132	CHRYSOBALANUS, <i>Linn.</i> <i>icrco, Linn.</i> .....	Cocoa Plum.....	30	North to latitude 27° 30'.
33 <i>g</i>	BUMELA, <i>Swartz.</i> <i>masticodendron, Roem.</i> <i>and Sch</i> .....	Mastic Plum....	50	Biscayne Bay.
111 <i>b</i>	CRESCENTIA, <i>Linn.</i> <i>(species undetermined)</i> .....	CALABASH-TREE. <i>Seven-year apple</i> .....	15	Biscayne Bay.
43	PERSEA? <i>Gaertner.</i> <i>(species undetermined)</i> .....	AMERICAN BAY-TREE. <i>White Bay</i> .....	30	Biscayne Bay.

No. 3 *b* is new to the United States, but not uncommon near the south end of Florida. It is well figured in Catesby's Carolina, Vol. II, page and plate 67, only differing in having broader leaves in Florida. The fruit is edible. Flowers in May in Florida. Specimens both of flowers and fruit, with leaves, &c., preserved in syrup, vinegar, or spirits, are very desirable, as the fleshy flowers fall to pieces when dried.

No. 132 is described in Torrey and Gray's Flora of North America, Vol. I, page 406, and is also figured by Catesby as "Frutex Cotini folio, &c." (Carolina, Vol. I, page and plate 25.) It abounds along the rivers surrounding the Everglades, and produces an agreeable fruit.

No. 36 *g* is also well figured by Catesby as the "Cornus foliis laurinis," (Vol. II, page and plate 75.) It is described in De Candolle's Prodrumus as a *Sideroxylon*, (Vol. VIII, page 181,) but the structure of the seed shows that it is really a *Bumelia*. It differs materially from *B. fetidissima*, figured by Nuttall in his continuation of Michaux's Sylva, as the specimens he described from plainly show. These are now in Professor Torrey's herbarium, together with most of the others sent from Key West by Dr. Blodgett.

No. 111 *b* differs from any species described in the latest works ac-

\* Supplementary to the article, by the author, in the Smithsonian Report for 1858, p. 246.

cessible; but as it is doubtless a West Indian species, I have hesitated to describe it. It resembles *C. obovata*, *Bentham*, from South America, but differs in form of leaves and flowers, as well as in color of the flower, which is dark purple. It might be named *C. atropurpurea*. The fruit of some species is eaten, but this is said to be poisonous, or disagreeable. *C. cujete*, figured by Nuttall, (from Key West,) is very different, and was not found on the main land by me.

No. 43 *b* is a common tree in the hummocks of South Florida, and resembles the *P. carolinensis*, except in having leaves smooth and shining beneath, flowers in terminal panicles, and other minor characters. It is probably described, but the specimens do not determine which it is, out of nearly two hundred tropical American species.

The Pigeon Plum, No. 113 *b*, (Florida list,) should be called *C. floridana*, *Meisner*, (in *De Cand. Prod.*) It is not *C. parvifolia* of Poiret, (whom Nuttall does not quote,) and that name is inappropriate, as its leaves grow to a length of six inches, and three wide. The figure in Nuttall's work is from a young-leaved specimen. That in Catesby's *Carolina*, Vol. II, page 94, is much better, and shows the fruit, "*Cerasus latiore folio*," &c.

The Palm mentioned by Nuttall in the introduction to his *Sylva* is found, as I was informed by several persons, in large groves, between Capes Sable and Romano, and one tree three miles north of Fort Dallas. It was called "Royal Palm," and said to grow 120 feet high. It is probably the Bahaman "Cabbage Palm," (*Oreodoxa oleracea*, *Mart.*) This was evidently the palm found by Bartram, in 1774, near Lake Dexter, on the St. John's river, latitude 28° 55', and to all appearance wild. Some were ninety feet high, with "plumed" (pinnate) leaves thirty feet in length. (*Travels*, page 114.) As no one has seen them lately, they may have been destroyed by the severe frosts of 1835.

The Orange, (*Citrus aurantium*, *Riss.*) is so universally spread in the forests of Florida as to be considered native by the inhabitants; but botanists generally think it was planted by the Indians at first, as all of the genus are thought to be natives of Asia. Bartram speaks of wild groves everywhere in his time; yet the Indians may have introduced it from Cuba more than two centuries previous. It has, perhaps, as much right to be called native as some of the other fruit-bearing trees here mentioned, which are less generally distributed. Its northern limit is about latitude 30°.

*Bursera gummifera*, (95 Florida list,) is called Gum Elemi, corrupted to "Gumbo limbo," in South Florida and the West Indies. It may be really one tree that produces that drug, all not being known to the latest authors on the materia medica. Catesby's figure, ("*Terebinthus major Betulæ Cortice*," Vol. I, page 30,) is better than that in Nuttall's *Michaux*.

No. 6 *e*, (Florida list,) is wrongly called "Manchineel" in South Florida, being confounded with No. 114, also a poisonous tree.

*Erythrina herbacea*, *Linn.*, assumes almost a tree form in Florida, growing twelve feet high, and is then scarcely distinguishable from *E. corallodendron*, the coral-tree of the West Indies, growing twenty feet high. Its wood is very light, corky, and may be of use in place of cork; but the latter has hard wood.



I also have wood and leaves of three or four other trees of South Florida, which seem to be undescribed as North American, and are not in Dr. Torrey's Herbarium.

Those interested may insert in their places the following localities as the southern or northern range of trees in Florida:

*Southern Limits of Northern Trees in Florida.*—Cape Sable, lat. about  $25^{\circ} 15' N.$ ; 1 *a*, 4 *b*, 9 *b*, 34 *a*, 53 *i l*, 62 *h*, 67, 71, 72.

Fort Dallas, lat.  $25^{\circ} 55'$ ; 49 *a*, (44. This was perhaps cultivated, as I saw it nowhere else.)

Fort Capron, lat.  $27^{\circ} 30'$ ; 8 *a*, 52 *e*, 53 *m*, 62 *e*.

At lat.  $28^{\circ} 30'$ ; 1 *h*, 21 *d*, 26, 33, 53 *c q*, 62 *i*, 68 *a*. On the St. John's river, about Lake Monroe, appear, 10 *d*, 11 *a*, 13 *a*, 19 *a b*, 27 *b*, 37 *a*, 40 *a*, 45 *d*, 53 *k*. Near Lake George, lat.  $29^{\circ}$ , are first seen 5, 6 *c*, 12 *c*, 38 *a b*, 53 *n*, 55 *b*. In Alachua county, about lat.  $29^{\circ} 30'$ ; 17 *a*, 25 *b*, 32, 36 *c*, 53 *t*. At the St. Mary's river, forming the northeastern boundary of the State, lat.  $30^{\circ} 25'$ ; 1 *e*, 2, 3, 15 *a*, 29, 30, 56, 57.

*Northern Range of Tropical Trees in Florida.*—To New Smyrna, lat.  $28^{\circ} 54'$ ; 98, 100, 102 *a*, 105, 106, 107. To lat.  $28^{\circ}$ ; 108, 113 *a*, 132.

To Fort Dallas, and probably much further north, 3 *b*, 4 *c*, 6 *e*, 36 *g*, 43 *b*, 91, 95, 96, 97, 102 *b c*, 110 *a*, 111 *b*, 113 *b*, 117 *b c*.

The following are the heights of some Florida trees: 4 *c*, 30 ft.; 91, 50 ft.; 95, 60 ft.; 6 *e*, 20 ft.; 102 *b c*, 40 ft.; 107, 60 ft.; 113 *a*, 30 ft.; *b*, 60 ft.; 117 *b*, 40 ft.; *c*, 30 ft.

Instead of 48 out of 78 of the trees being evergreen in Florida, as stated on page 32, my late observations show that 70 out of 108 are so, or about two-thirds. 9 *b c* (34 *a*?), 67 (49?), 44 *a*, 52 *e*, 95, are all the deciduous trees found south of lat.  $28^{\circ}$ , and it is doubtful whether some of these *do* lose their leaves there.

With regard to the distribution of its *forests*, Florida may be transferred to the group of regions "*completely wooded*," for there are no parts of it unwooded, like the western prairies, on account of dryness. The so-called "*Prairies*" of Florida are more properly *Savannas*, the growth of wood being prevented by inundation. They become more or less dry during the dry season, (winter,) and are then excellent grazing lands. The *Everglades* consist, in fact, of similar savannas, of lower level than those further north, and therefore almost constantly overflowed. A gradual extension of the forest is taking place along their southeastern border, as shown by the successively younger trees, and this *may* indicate a slow rising of the land there.

But near New Smyrna I was shown a pond with dead pines on its borders of a few years' growth. Mr. Carpenter, a resident there for nearly twenty years past, attributed this to the irregularity of the seasons, several dry ones having occurred in succession, when the trees grew, and then a series of very rainy years, which killed them by inundation. This agrees with the recorded observations of the seasons in Florida, and I have no doubt is the true explanation.

NOTE.—It is scarcely necessary to observe that the range of trees here given is their natural range only. The extension of this by cultivation may form the subject of a subsequent paper, and facts relating thereto will be gladly received.

By an oversight the following trees were omitted from the list of those on the Mexican boundary:

No., &c.	Botanical name.	Popular name.	Height.	Range.
98 c	ACACIA, <i>Wild.</i> <i>greggii, Gray.</i> .....	ACACIA. Gregg's . . . . .	20	Pecos R., Tex., to Warner's Pass, Cal.
110 c	CORDIA, <i>Plumier.</i> <i>boissieri, A. D. C.</i> .....	Is not 110 a, p. 21.) Nacavites (Mex.)....	20	On Rio Grande to Salado river, Mex.
62 w z y	PINUS, <i>Tourn.</i> <i>deflexa, Torr.</i> ..... <i>chihuahuana, Englm.</i> ... <i>torreyana, Parry.</i> .....	PINE. <i>Claw-scaled</i> ..... <i>Chihuahuan</i> ..... <i>Torrey's</i> .....	50 50 50	Sierra Madre, N. M., to Cajon Pass, Cal. Sierra Madre, N. M. Near San Diego, Cal.
133	BRAHEA? <i>Mart.</i> <i>dulcis? Mart.</i> .....	California Palm.....	30	Lat. 34° 20' Cal., south.

133. Dr. S. Hayes collected leaves of this Palm at Palm Springs, Cal., but it is not mentioned in any of the Reports on Botany of that region. It has numerous threads along the edges of the leaves, which otherwise much resemble those of the Palmetto (No. 71). The leafstalk is prickly, and the fruit edible. It is used by the Mexicans to make hats, &c., and is a common species in Sonora, where it is said to grow one hundred feet high. Major Emory, Mr. Blake, and others, refer to it in their reports.

ERRATA AND CORRECTIONS IN THE ARTICLE BY DR. COOPER, IN THE SMITHSONIAN REPORT FOR 1858—PAGES 246-280.

Page	2,	line	1,	for <i>their</i> read <i>its</i> .
"	4,	"	20	from bottom, for <i>deviled</i> read <i>detailed</i> .
"	6,	"	4	from bottom, CAR. read CDA.
"	9,	"	22,	omit <i>or V</i> .
"	9,	"	23,	for <i>HALESEA</i> read <i>HALESIA</i> .
"	9,	"	24	for <i>Ky.</i> read <i>Ind.</i>
"	9,	"	33 and 36,	for <i>Braunfels</i> read <i>Brunswick</i> .
"	10,	"	28,	for 24 <sup>o</sup> read 44 <sup>o</sup> .
"	13,	"	26,	for 3's read 5's.
"	13,	"	33,	for <i>river</i> read <i>Russian</i> .
"	13,	"	33,	for <i>Beat</i> read <i>Brit. Am.</i>
"	17,	"	11,	for <i>joints</i> read <i>points</i> .
"	17,	"	15,	for <i>chryophylla</i> read <i>chrysophylla</i> .
"	17,	"	53 f	belongs to 53 i.
"	17,	"	62 q	includes <i>tuberculata</i> and <i>radiata</i> , Don.
"	17,	"	62 n	includes <i>edgariana</i> , Hartw.
"	21,	"	18	from bottom, for <i>Schinus</i> read <i>Schinus</i> .
"	22,	"	12,	for <i>Loma</i> read <i>Coma</i> .
"	22,	"	49 b	is probably the same as 49 a, p. 10.
"	24,	"	10,	for <i>equatorial</i> read <i>spheroidal</i> .
"	25,	"	7,	for <i>these</i> read <i>those</i> .
"	26,	"	11,	for <i>of</i> read <i>in</i> .
"	26,	"	13,	for <i>groups</i> read <i>groves</i> , or.
"	26,	"	21,	for <i>number larger</i> read <i>number appear larger</i> .
"	26,	"	22,	for <i>Kootanic</i> read <i>Kootanie</i> .
"	27,	"	20,	for <i>Corifera</i> read <i>Comifera</i> .
"	28,	"	22,	for <i>depending</i> read <i>founded</i> .
"	29,	"	10	from bottom, for 30 <sup>o</sup> read 30.
"	30,	"	23,	for <i>its</i> read <i>the</i> .
"	30,	"	33,	for <i>products</i> read <i>features</i> .
"	33,	"	18,	for <i>streams</i> read <i>storms</i> .
"	34,	"	20	from bottom, for <i>outlines</i> read <i>outliers</i> .
"	35,	"	13,	for <i>region</i> read <i>regions</i> .
"	36,	"	13 and 21,	for <i>Caurian</i> read <i>Caurine</i> .

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