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A practical course in biology.

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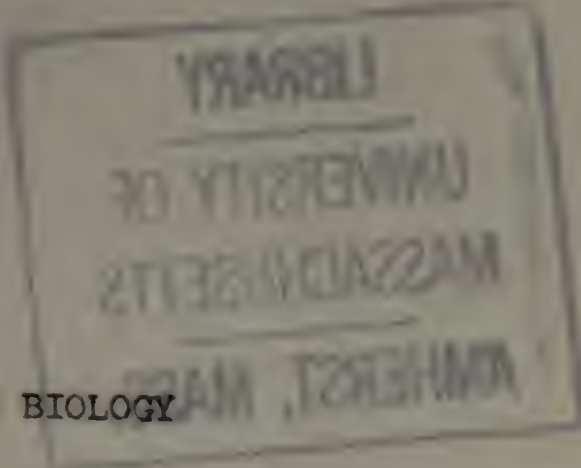
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A PRACTICAL COURSE IN BIOLOGY



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A PRACTICAL COURSE IN BIOLOGY

by

ELMER T. KOSTER

Problem submitted in partial fulfillment of the requirements for the Master of Science degree in the Graduate School of the Massachusetts State College

Amherst, Massachusetts
1941

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A PRACTICAL COURSE IN BIOLOGY

CHAPTER 1
THE PROBLEM

CHAPTER 1

THE PROBLEM

(1) Statement of Problem: This investigation is made to formulate a practical course of study in general biology which will serve the needs of "slow" pupils; that is, those pupils who have been classified in the lower mental ability groups. This course is to be used with low mental ability groups in the Benjamin Franklin High School at Rochester, N. Y. The study purposes also to make an analysis of difficulties existing in the present course of study as taught in the Benjamin Franklin High School, and to indicate how these difficulties may be overcome.

The following pertinent questions are given consideration in the investigation:

1. What is the organization of the Benjamin Franklin High School in which such a course of study is given?
2. What are the objections to the present course of study in general biology for "slow" pupils of this school?
3. What trends in the development of general biology since 1900 have influenced the content of the course, the objectives of the course, and the methods of teaching?
4. How are the present objectives of general biology related to the general objectives of education?

5. What are the advantages and limitations of teaching biology by each of the following methods?
 - (a) Lecture method.
 - (b) Book and recitation method.
 - (c) Teacher-demonstration method.
 - (d) Individual laboratory method.
6. What are the merits of the general methods of arrangement and presentation of subject matter?
7. How does the proposed course meet the objections to the present course?
8. What further investigations should be carried on to improve the proposed course?

FACTORS LIMITING ORGANIZATION OF THE COURSE

(2) N. Y. S. Syllabus: In New York State, state syllabi are provided for all academic subjects, including biology. These syllabi do not outline the subject matter for "slow" pupils as, obviously, such pupils cannot be required to meet the rigid requirements of the New York State Regents Examinations. However, in the present study the writer has endeavored to follow in the general spirit of the state syllabus in biology, although a different arrangement of subject matter has been used and the content varied to serve the needs of the pupils of lower ability.

(3) Rochester City Syllabus: The Rochester City Syllabus outlines the same subject matter as the state syllabus. Whereas, the state syllabus provides only a very general outline of subject matter to be studied, the city syllabus

outlines the same subject matter in detail, separating the large units into small parts and arranging them under major and minor concepts. The city syllabus makes provision for low ability groups by designating some topics as suitable for low ability pupils, and others to be used in the academic classes only. The topics thus selected for "slow" pupils comprise the present course of study given in the low ability classes.

The writer has endeavored to include in the proposed course of study most of the subject matter now used for "slow" pupils. However, the arrangement and organization differ.

(4) Transfer of Students: Theoretically, transfers from the "slow" classes to the regular classes, and vice versa, should be easily accomplished in order to permit continuous pupil adjustment. It is argued that courses for both "slow" and regular classes should contain the same subject matter, arranged in the same sequence so as to permit such adjustments with the least loss to the pupil. However, in practice very few transfers from the regular classes in biology to the "slow" classes are made during the year, and none are made from the "slow" groups to the regular classes. Considering these facts, the writer has not tried to arrange a course of study for the "slow" groups which parallels the course used with the regular groups. He has kept in mind the needs of the "slow" groups and how best to serve them, whether the courses are parallel or not. The subject matter in the proposed course, however, does not greatly differ from that of the present course used in the "slow" groups, excepting in arrange-

ment. Transfers from the regular classes to the "slow" classes can be made with as much ease as at the present time.

(5) Grade of Course: The course is prepared for pupils of the tenth year who have completed one year of general science in the ninth year.

ORGANIZATION OF THE REMAINING CHAPTERS

Chapter 2 contains a discussion of the organization of the Benjamin Franklin High School, including the segregation of pupils into ability groups, the organization of the biology courses, and the arrangement of the subject matter to serve the needs of the different ability groups. A discussion of a special phase of biological work done in the Plant Laboratory Club, which is carried on as an extra-curricular activity, is also included.

Chapter 3 traces the history of general biology since 1900 to indicate changes in emphasis on subject matter and the development of teaching objectives as a basis for the present day objectives in teaching biology.

Chapter 4 summarizes the present day objectives of biology teaching as found in available literature, with special reference to those stated in the Rochester City Syllabus, for use by the city teachers. A discussion of the relation of biology objectives to those established for general education is included.

Chapter 5 includes a discussion of the following methods of teaching biology:

(a) Lecture method.

(b) Textbook recitation method.

(c) Teacher-demonstration method.

(d) Individual laboratory method.

Chapter 6 considers the relative merits of two methods of arranging subject matter:

(a) Systematic arrangement, in which the subject matter is grouped around the study of individual plants and animals as types.

(b) Functional arrangement, in which the subject matter is arranged around life functions as they are carried on by both plants and animals.

Chapter 7 contains an analysis of the proposed course of study to determine:

(a) The relationship between the subject matter for the proposed course of study, the objectives established for teaching biology, and the objectives for general education.

(b) The adaptability of the subject matter to the pupils' ability.

(c) How the proposed course of study remedies defects evident in the present course, and whether it is in harmony with the principles of teaching which are pedagogically sound and scientifically correct.

Chapter 8 summarizes the entire investigation, and presents problems for further study.

CHAPTER 2

SCHOOL ORGANIZATION

CHAPTER 2

SCHOOL ORGANIZATION

(1) Ability Groups: Pupils of the Benjamin Franklin High School are classified into two main groups according to their mental ability. One group is composed of the academic or more capable pupils; the other, of "slow" pupils, or those of lower mental ability. Such classification is based on a series of intelligence tests, report card marks, and the opinions of class-room teachers.

Academic pupils pursue regular courses of study as outlined by the New York State Syllabi. All those who expect to enter college or other institutions of higher education must pursue these courses.

"Slow" pupils pursue parallel courses of study in the academic subjects. These courses are similar to the academic courses except that they have been amended by omitting the more difficult subject matter and changing the content to make them conform to the needs of "slow" pupils. This group includes those who do not expect to enter college or pursue their formal education beyond high school.

(2) Biology Courses for Ability Groups: The present plan in biology for meeting the needs of pupils of the different ability groups is to use the same syllabus for all groups, omitting the more difficult topics for the "slow" pupils, and suggesting additional topics for "superior" pupils.

From the Rochester City Syllabus in biology,

(12,1)*, the writer quotes the following:

"This syllabus is organized to serve the needs of three groups of pupils; namely, superior, average, and non-Regents** pupils, designated respectively by the letters "S", "A", and "M". Those items marked "SAM" will be known as "Science for Sam and Mary", and are considered suitable for non-Regents pupils. These items will serve also as the minimum for all pupils. Items marked "SA" are to be required of all average and normal groups of pupils in addition to the "SAM" items. All "S" items may be used as enrichment items for average pupils, or required items for superior pupils."

(3) Criticisms of Present Plan: This plan as applied to the present biology course is not satisfactory for "slow" pupils.

First, the unity and continuity of the subject are lost when certain topics are omitted. The writer has found it impossible to teach some topics assigned to "slow" groups, because subject matter leading up to these topics has been previously omitted, such subject matter having been designated for regular groups only. For example, in Unit II, (12,16), of the city syllabus, the study of cells for "slow" pupils is completed with the information that living things are composed of cells which are microscopic in size. No study of cell structure is indicated. On page 18 is the following problem marked for all pupils:

"SAM. Problem--How do animal cells differ from plant cells?"

* The first number refers to the number of the reference in "Literature Cited;" the second, to the page of the reference.

** Non-Regents Pupils ---- Pupils who are considered as the "slow" pupils.

- A. Absence of cell wall
- B. Absence of chlorophyll - - prevents manufacture of food.
- C. Centrosomes - - used in mitosis."

On page 19, (12,19), although the process of cell division as a growth process is marked for normal groups only, on the same page, cell division occurring in roots is marked for all groups. Further analysis of the syllabus will indicate many other similar inconsistencies.

The course should be coherent and unified, and should not consist of a selected list of topics taken from a more difficult course and altered to meet the needs of "slow" pupils. It should be adapted to the pupils' ability, and work should be completed with the same degree of thoroughness as is required of regular classes.

Second, the "slow" pupil's lack of ability is emphasized when he compares the work done in his class with that done in the regular classes. His inferiority is constantly brought to his attention and he does not receive the satisfaction of having completed any task. Pupils have often reported that they are not expected to complete a certain piece of work as given in the regular classes, because they are "dumb".

The course should be arranged and adapted to the needs and abilities of "slow" pupils, so that direct and odious comparisons are not extant.

Third, the present course does not provide either sufficient opportunity for laboratory work or for observational study of living plants and animals. An analysis

indicates that 85 per cent of the subject matter is composed of abstract material, e. g., Unit I requires six weeks for completion and contains only two problems which deal with concrete material suitable for laboratory work. These two problems mentioned are:

1. "Make a list of the different living things found in a three-foot circle in your back yard (or any other definite area)."
2. "Make a list of the different environments with which you are acquainted and list the things which you find living there; e. g., swamps, rivers, fields"

All the remaining subject matter in Unit I deals with abstract material; namely,

1. Classification of man into races.
2. The origin and evolution of man.
3. Man's use of plants and animals.
4. Classification of plants and animals.

The use of concrete material, which is an important aid in teaching regular groups, becomes a vital necessity in teaching "slow" groups. One reason for placing pupils in "slow" groups is that they can neither read understandingly nor comprehend abstract ideas from the printed page. The only real approach to them is through a study of objective material. Therefore, any course designed to serve the needs of "slow" pupils should suggest an abundance of concrete material for observation, demonstration, and experimentation.

(4) Plant Laboratory Club: A special phase of

biological work in the Benjamin Franklin High School is carried on through the Plant Laboratory Club working in the school greenhouse. A picture of these pupils at work after school is shown on Plate I. This is an extra-curricular activity. Membership in the club is open to any pupil of the school who is interested in the care and propagation of plants. Although all work must be done outside of regular school hours and no school credit is given for such work, from seventy-five to ninety members carry on experiments with plants and animals similar to that outlined in the regular biology course. Membership in the club is limited only by the facilities to accommodate. There is a constant waiting list of from seventy-five to one hundred pupils wishing to join as soon as an opportunity may occur.

The intense interest manifested by the pupils of the Plant Laboratory Club, which has been in charge of the writer for the past seven years, has suggested that this interest might be transferred to the biology classes. This interest appears to be due to the fact that these pupils are working with concrete, objective material in studying living plants and animals. It is evident to any one who has taught or observed children that they have the greatest interest in those things which they can see and handle. They prefer concrete experiences, and few subjects present greater opportunity for the study of concrete material than biology.

Club members get the feeling of self confidence and security that comes with accomplishment. Regardless of the degree of ability or lack of ability by any individual, each

one knows that he can contribute something to the program of the club and that there is an appreciation of his contribution, however small. In doing work of this kind, understanding is substituted for book learning; proof, for indoctrination; and reasoning, for dogma and emotion.

The writer is convinced that a course of study in general biology which will permit pupils to observe and study living plants and animals directly related to their lives, and so arranged that the maximum amount may be studied by a laboratory method, will succeed in arousing a similar interest among biology pupils.

(5) Summary: Pupils of the Benjamin Franklin High School are classified into ability groups, and the courses of study are arranged accordingly.

The course of study in biology for low ability classes is formed by omitting the more difficult topics from the course of study used in regular classes.

The following criticisms of this arrangement are given:

1. The continuity of the subject matter is destroyed.
2. This arrangement tends to create a feeling of inferiority among the pupils of the low ability classes.
3. Sufficient opportunity for laboratory work is not provided.

The Plant Laboratory Club suggests methods of improving the technique of teaching biology.

LEGEND

Figure I. In May the greenhouse is filled with mature plants which are propagated by pupils during the year. These plants will soon be taken home for use in window boxes or home gardens. Partitions in the bench indicate the boundaries of individual's plats.

The girl who has plat 55 is inspecting her geraniums. The two girls in the background are taking notes in an experiment in pollination. The boy in the foreground is receiving individual instruction.

The varied interests of the pupils is evident from the variety of plants grown. Coleus, geraniums, ageratum, calendula, zinnia, asters and many others are produced for home gardens. Sanseveria, begonia, dracena, aloe, cactus and others are grown as pot plants.

Figure II. The greenhouse as it appears in October. Young plants are started from cuttings and seeds. Each individual plans his work according to his own interests.

In the right foreground a boy is working on a seed testing project for one of the local seed firms. In the left foreground is a garden pool constructed of cement. This is an imitation of one which might be used outside. Aquatic plants and animals are cared for in the pool. At the rear of the pool, one pupil has arranged strings upon which morning glories may grow. The three boys near the pool are testing cuttings in order to determine whether they have produced sufficient growth to be transplanted. Other pupils may be seen engaged in various activities.

PLATE I

PUPILS OF THE PLANT LABORATORY CLUB
EXPERIMENTING IN HIGH SCHOOL GREENHOUSE

Figure I



Figure II



CHAPTER 3

THE DEVELOPMENT OF BIOLOGY

CHAPTER 3

THE DEVELOPMENT OF BIOLOGY

(1) Increase in Enrollment in Biology: General biology courses were first offered in the high schools of the United States late in the nineteenth century, supplanting the older and more specialized courses in botany, zoology, and physiology. Stout, (39,6), reports that biology was offered in the high schools of Milwaukee for the first time between 1881 and 1885, and in Chicago and Cadillac between 1891 and 1895. Hunter, (31,32), states that, "The first course in elementary biology in this country seems to have been prepared by the Regents of New York State, and first offered in 1899." The 1936 syllabus in general biology((10,5) for New York State states, "The first syllabus in biology in this state was issued in 1905." According to statistics compiled by Stout, (39,72), biology was offered by 10 per cent of the schools in the North Central States in 1900.

Several recent studies have been made which reveal a gradual rise in biology enrollment in various parts of the United States since 1900.

Table I (21,319) shows the percentages of the California day schools offering botany, zoology, physiology, and biology for the years 1907 to 1923. From this table it is evident that the percentage of the California schools offering botany diminished from 30 per cent in 1907 to 10 per cent in 1923. During the same period the percentage offering zoology diminished from 10 per cent to 3 per cent, physiology

TABLE I

Percentages of the California Day Schools Offering
The Biological Sciences for the Years 1907-1923 (21,319)

School Year	Percentage of Schools offering			
	Botany	Zoology	Physiology	Biology
1907-1908	30.6%	10.2%	2.7%	1.7 %
1908-1909	28.6	10.7	3.6	-----
1909-1910	27.4	9.9	8.0	.47
1910-1911	30.4	12.0	7.4	1.40
1911-1912	31.4	12.9	10.1	1.40
1912-1913	28.4	12.7	16.2	3.90
1913-1914	31.8	17.2	11.7	.42
1914-1915	32.6	17.5	13.5	2.70
1915-1916	27.1	12.8	13.2	9.00
1916-1917	19.9	5.3	13.2	31.70
1917-1918	16.7	6.0	16.4	40.00
1918-1919	14.4	4.6	15.4	45.80
1919-1920	11.5	4.5	17.4	46.00
1920-1921	8.9	2.7	14.0	47.10
1921-1922	9.2	3.6	12.1	56.80
1922-1923	10.1	3.2	13.3	59.50

increased from almost 3 per cent to 13 per cent, and biology, from 1.7 per cent to 59 per cent. It shows a gradual decline in the enrollment in botany and zoology, and an increase in general biology. The sudden increase in the number of schools offering biology in 1916-1917 and the corresponding decline in the number offering botany and zoology was caused by the University of Southern California withdrawing its support of botany and zoology as separate subjects and transferring it to biology.

Table II presents the results of Monahan's studies (36,876) concerning the percentage of high schools in the United States offering courses in the biological sciences. He obtained this information from the U. S. Bureau of Education. It was compiled from statistics gathered from 14,725

TABLE II

Comparative Enrollment of Biological Science Students in the Schools of the United States for Years 1915, 1922, 1928

Subject	1915	1922	1928
Biology	6.9%	8.8%	13.6%
Botany	9.1	3.8	1.6
Zoology	3.2	1.5	.8
Physiology	9.5	5.1	2.7
General Science	0	18.3	17.5

high schools. It is to be noted that the number of schools offering biology was doubled in the period 1915-1928, while the number offering botany, zoology, and physiology decreased. Also, general science became an established subject.

(2) Enrollment in Biology in New York State: In Table III compiled from the annual reports of the State Department of Education, (2,17:3,17), the gradual increased enrollment in biology and general science in New York State during the years 1916-1934 is reported. The enrollment in general biology increased from 49,349 in 1916 to 92,155 in 1934, while general science increased from 128 in 1916 to 91,422 in 1934. During this same period botany and zoology nearly disappeared from the curricula of the high schools of New York State. The more general subjects, general science and biology, have gradually supplanted the more specialized subjects, botany and zoology.

Consideration of physiology as a special subject has been omitted from this table because in New York State, as in many other states, the State Legislature makes the teaching of physiology mandatory in the high schools. In many schools

TABLE III

Pupils of N. Y. S. High Schools
Registered in Biological Sciences
1916-1934

Year	Botany	Zoology	Biology	Gen. Science
1916	5,120	3,321	49,349	128
1918	2,618	1,900	45,655	62
1920	1,277	981	49,959	313
1922	502	1,119	70,260	1,341
1924	545	1,869	72,047	335
1926	267	2,261	89,405	17,593
1928	440	526	90,811	25,657
1930	227	183	104,542	37,816
1932	-----	239	107,528	61,150
1934	-----	84	92,155	91,422

this requirement is fulfilled by special courses in physiology and hygiene given in the physical education department.

A summary of these tables indicates that general biology and general science have almost entirely supplanted the older courses in botany and zoology, and the development in New York State closely parallels the development in the nation.

(3) Grade Placement of Biology: Although there is apparently a great lack of uniformity in the high schools of the nation as to the year in which biology is placed, many investigations indicate that the trend is toward placing it in the tenth year. Biology, which was generally introduced as a ninth year subject, was changed to a tenth year subject in those schools which added general science to the curriculum as a ninth year subject.

Table IV, from Christy (21,329), depicts the grades in which the high schools of the Eastern States offered

TABLE IV

Comparison of the Grade Placement of Biology and General Science in the Eastern States, 1908, 1923, 1930

Grade	Year	General Science	Biology
9	1908	2.50%	10.00%
	1923	53.10	16.09
	1930	66.80	18.80
10	1908	-----	7.25
	1923	1.93	48.13
	1930	6.40	45.30
11	1908		6.29
	1923		6.88
	1930		4.50
12	1908		9.01
	1923		5.97
	1930		6.80

general science and biology. In 1908, only 2.5 per cent of the high schools offered general science, but in 1930 73 per cent were offering general science, and 60 per cent of these offered it in the ninth year. In 1908, 32 per cent of the schools were offering biology, placed with approximately equal frequency in each of the four years of high school. In 1930, 75 per cent of the schools were offering biology, and of these 45 per cent were offering it in the tenth year, and 19 per cent in the ninth year. From this table it is evident that general science is definitely established in the ninth year, and although the grade for biology has not been so well established, the tendency has been to assign it in the tenth year.

Hunter, (30,765), states that, "While the place of biological science is not fixed in all parts of the country, biology as a unified science has an established position in

the tenth year."

(4) Grade Placement in New York State: Biology, in New York State, was first offered as a ninth year subject, called Elementary Biology, which replaced the older subjects, botany, zoology, and physiology. Elementary Biology in the ninth year was gradually displaced by general science, and a new course called General Biology was prepared and offered in the tenth year.

At the present time, general science is established in the ninth year, and is a required subject in all high schools. General Biology is established in the tenth year.

(5) Subject Matter: During this period, the subject matter of the biology courses was gradually changed from the specific and detailed study of morphology and physiology to the more general considerations of the relation and economic importance of plants and animals to man.

(6) Early Courses in N. Y. S.: Early courses in biology were generally contractions of the older courses in botany, zoology, and physiology. For example, in New York State the first syllabus in biology, (4,105), prepared by the Regents Board contains the following statements:

"For all schools that have adequate laboratory equipment, and teachers of requisite scientific training, a first year course in biology consisting of some study of botany, zoology, and human physiology is recommended. Some of the reasons for such a course are as follows:

1. "The natural interests of students, on entering high school are extensive rather than intensive, hence, a course in science dealing with a wide range of facts appeals to boys and girls more strongly than does a more

thorough consideration of a smaller number of topics.

2. "It is advantageous for students to study both animals and plants, because in this way, only, can the essential processes that underlie the phenomena of life be emphasized."

New York State continued this tripartite arrangement of the ninth year elementary biology syllabus from its first publication in 1905 through several revisions, until approximately 1930. The 1905 syllabus was divided into three main parts; namely, (1) Botany, (2) Physiology, (3) Zoology. The 1905 syllabus was revised in 1911 and contained four parts; namely, (1) Introductory Topics, (2) Animal Biology, (3) Human Biology, (4) Plant Biology. In 1921 the syllabus was again revised and one more part added to the four parts of the 1911 syllabus. This part was termed General Biology. It was composed of miscellaneous generalizations concerning plants, animals, and man; such as, protoplasm and cell structure; interrelation of plants, animals, and man; and community problems.

(7) Present Course of Study in N. Y. S.: In 1931 a New York State syllabus was prepared for use in tenth year biology. To avoid confusing this course with the old Elementary Biology given in the ninth year, and the Advanced Biology given in New York City, it was called General Biology. This syllabus, with some minor changes made in 1936, is in use at the present time. The subject matter and its arrangement were completely changed and grouped into eleven large units, each one of which is intended to present a broad biological generalization. The eleven generalizations are

as follows:

1. "Man is one species among millions of diverse species."
2. "There is unity among all living things."
3. "Living things and their environment are constantly changing."
4. "All living things have the same problems."
5. "Living things bear different nutritional relations to their environment."
6. "Living things have to be able to relate themselves to their environment."
7. "Reproduction is race preservation."
8. "Variation and heredity are the bases for race modification."
9. "Man is learning to control and improve his environment."
10. "Man makes use of biological discoveries in understanding his own body and in promoting his health."
11. "The progress of man is a biological phenomenon."

(8) Changes in Course of Study in N. Y. S.: The general trend in the development of subject matter in biology textbooks has been away from the specific problems concerned with taxonomy, morphology, and physiology of plants and animals toward the establishment of broad generalizations. An analysis of the percentage of space devoted to different phases of subject matter is shown in Table V (20,277). From this table it is evident that the amount of space devoted to taxonomy and morphology has decreased to approximately one-third the

TABLE V

Percentage of Space Devoted to the Different Phases of Subject Matter (20,277)

Author*	Year	Tax- onomy	Morph- ology	Nat. Hist.	Ecol- ogy	Physio- logy	Health	Here- dity	Appre- cia- tion	Pract. Appli- cation	Misc.
Hunter	1907	16.37	39.99	3.67	9.32	6.27	9.05	0.05	1.49	4.62	3.96
Bailey & C.	1908	11.79	39.36	9.50	4.74	16.28	8.85	0.55	0.26	5.96	2.67
Peabody & H.	1912	6.90	23.16	6.54	1.29	11.08	19.25	1.57	7.09	17.32	2.54
Hunter	1914	5.33	10.37	2.00	6.29	21.16	25.99	4.52	8.36	12.39	3.12
Hodge & D.	1918	12.95	2.23	12.93	0.89	0.21	13.26	4.68	14.16	35.98	2.42
Moon	1921	6.01	27.40	13.28	2.53	14.65	13.78	1.76	6.97	9.89	3.71
Atwood	1922	5.58	22.81	12.53	6.77	9.12	8.86	9.76	2.71	16.90	4.83
Clement	1924	4.73	12.33	8.47	3.74	27.13	20.34	3.28	5.12	10.19	4.62
Gruenberg	1925	6.14	13.59	3.98	4.42	13.48	29.00	7.08	6.11	12.91	7.54
Atwood	1927	9.04	19.91	9.65	7.63	7.15	9.14	6.60	9.76	18.84	2.11
Meier & M.	1931	11.46	23.29	11.25	4.40	8.92	12.16	3.08	8.37	16.08	1.30
Peiper et al	1932	5.94	14.93	13.06	15.15	15.96	10.58	3.68	5.46	14.93	5.61
Wheat	1932	3.63	11.48	9.92	10.72	14.80	5.30	11.74	13.44	14.38	4.60
Kinsey & M.	1933	7.45	8.23	14.40	19.91	5.13	8.66	7.86	12.76	9.83	6.43
Baker & M.	1933	4.67	3.73	20.46	9.23	6.93	11.20	7.27	16.28	7.11	2.97
Mank	1933	6.73	14.30	8.32	9.20	17.69	13.94	4.47	7.68	13.23	4.58
Fitzp'k. & H.	1935	5.82	11.79	11.89	10.16	17.75	7.23	7.79	8.11	9.66	4.00

*The textbooks given in the table by the authors' names are:

Hunter, G.W.	Elements in Biol.	1907	Atwood, W.H.	Biology	1927
Bailey, L.H. & Coleman, W.M.	First Course in Biol.	1908	Meier, W.H.D. & Meier, L.	Essentials of Biology	1931
Peabody, J.E. & Hunt, A.E.	Elem. Biol.	1912	Peiper, C.J., Beauchamp, W.L., & Fish, O.D.	Every Day Problems in Biol.	1932
Hunter, G.W.	A Civic Biol.	1914	Wheat, F.M. & Fitzp'k., E.T.	General Biol.	1933
Hodge, C.F. & Dawson, J.	Civic Biol.	1918	Kinsey, A.	New Introduction to Biol.	1933
Moon, J.T.	Biol. for Beginners	1921	Baker & Miles	Dynamic Biology	1933
Atwood, W.H.	Civic & Economic Biol.	1922	Mank, H.G.	The Living World	1933
Clement, A.G.	Living Things	1924	Fitzp'k., F.L. & Horton, R.E.	Biology	1935
Gruenberg, B.C.	Biol. & Human Life	1925			

amount given to these topics in the earlier books. Also, the amount of space given to heredity, appreciation, and practical applications has approximately doubled, while natural history, ecology, and physiology have been given about the same space throughout the entire period.

(9) Laboratory Work: In the older courses of study, individual laboratory work by the pupil was emphasized. Each pupil was required to examine specimens, to make and record observations, and to carefully prepare a notebook containing elaborate and detailed drawings of all specimens studied. For example, the following instructions were included in the New York State Biology Syllabus for 1906 (4,105).

"Individual students should be supplied with a specimen of each of the forms studied.

"So far as possible, the experiments should be performed by the individual students. Demonstration of the more difficult experiments should be done by the teacher.

"Too much emphasis cannot be laid upon the importance of actual specimen study. Textbook study alone of plants and animals means the waste of time and energy of student and teacher alike."

In the New York State Biology Syllabus of 1936, in use at the present time, no mention is made of laboratory work. Emphasis is placed on teaching "large biological truths" (10,6). "The syllabus represents a social point of view integrating the field of biology with fundamental values in other fields," (10,6). An attempt is made to group the subject matter around man as the center of interest. "If the motif for the ninth year was 'man as an individual

in relation to his environment' for this tenth year work the motif may be stated 'man as a species in relation to his environment.' It is again assumed that such an organization, centered in man, will be psychologically most interesting," (10,8).

In the present syllabus, approximately 15 per cent of the list of "suggested activities" includes the old type of laboratory experiment which was demanded in the earlier courses for the satisfactory completion of the work. The remaining 85 per cent consists of "exercises" which require the pupil to collect and record data from the textbook, reference reading, observation of pictures, charts, and models, or information concerning social and community problems with which he may be familiar or which may be suggested to him. A carefully prepared notebook is no longer required. Pupils are encouraged to keep a notebook, but mostly for their own use.

(10) Objectives: The dominant aim in education was mental discipline when biology was introduced to the American high schools. In 1904, Lloyd and Bigelow, (34,9), state, "The mental discipline by which the generalizations of science have been attained are, however, the normal operations of the human mind, refined and applied with accuracy. Indeed, an important lesson which we learn from science is the great value of these mental operations when so controlled." Again he writes, (34,5), "We propose to show that biology has a special value in education because of the discipline which it gives to the mind engaged in study."

When the experimental psychologists (38,278) had succeeded in destroying the mental discipline aim, a basis for new objectives had to be found. Educators began to stress the importance of relating objectives to human welfare, and the mental discipline was succeeded by a series of practical aims; such as, (1) To maintain health, (2) Interesting features of the environment, (3) Worthy use of leisure time, (4) The importance of science and scientists in the world, (5) Development of a scientific attitude. A further discussion of objectives is taken up in the chapter following.

(11) Summary: The growth and evolution of general biology in the high schools of the United States have been presented in this chapter. Special consideration has been given to the biology taught in New York State because this course of study outlined by the writer is to be used in a New York State High School.

General biology was introduced into the American high schools during the latter part of the nineteenth century, displacing the older subjects, botany, zoology, and physiology. Since 1900 the number of schools in which biology is taught has gradually increased until general biology is the leading biological science in the American high schools.

General biology and general science have almost entirely taken the place of botany, zoology, and physiology in high schools of New York State.

Although biology is offered in the ninth, tenth, eleventh, and twelfth grades in different schools, the

majority are offering it in the tenth grade.

In New York State, the Board of Regents had definitely established General Biology as a tenth grade subject, and General Science as a ninth grade subject.

The subject matter of the biology courses has been gradually changed. Emphasis on taxonomy, morphology, and physiology has given way to the development of broad generalizations. More attention is given to practical application and the economic relationship of plants and animals to man.

The old objective of mental discipline has been discarded, and practical objectives more closely related to human welfare have taken its place.

CHAPTER 4

OBJECTIVES

CHAPTER 4

OBJECTIVES

(1) Educational Objectives: Biology is offered as one of the subjects of secondary education; therefore, the objectives of biology must be closely related to the general objectives of secondary education. Just as each of the other subjects in the curriculum contributes its part toward the education of the individual, so biology must make its contribution. A consideration of the general objectives of education becomes necessary, then, in order to establish the goal to which biology must contribute.

The list of objectives generally accepted for education is that proposed by the committee of the N. E. A. enumerating the seven cardinal principles of secondary education as follows:

1. Health
2. Knowledge of the Fundamental Processes
3. Worthy Home Membership
4. Good Citizenship
5. Wise Choice and Efficiency in Vocations
6. Wise Use of Leisure
7. Moral Integrity

(2) Objectives in Science: That the lists of science objectives do not differ greatly from those of general education is evidenced by the fact that the Committee on the Reorganization of Science (20,276) used six of the seven cardinal principles as the main objectives of science teaching.

Good citizenship was the only one omitted in the science list, although it is difficult to determine why an understanding of such science topics as conservation of our national forests, quarantine regulations to prevent the spread of contagious diseases, purification of community water supplies, and others of a similar nature should not contribute their part toward producing an intelligent citizen.

(3) Objectives in Biology: In the teaching of biology, as in the teaching of other subjects, a definite statement of the objectives to be attained is essential before any real measure of accomplishment can be realized. The teacher must know what objectives are to be attained in order to know how to proceed toward them or how to recognize them when they are reached. Whether the goal is the acquisition of certain information or the establishment of certain habits, skills or attitudes, the problem is the same. It resolves itself into three parts; namely, (1) What is to be taught?, (2) How should it be taught?, (3) Are the desired objectives being successfully attained?

Individuals, authors of textbooks, committees of teachers and research workers have attempted to formulate comprehensive lists of objectives for the teaching of biology. Such lists may be found in textbooks, courses of study, committee reports, and publications of research articles. They vary in length from one simple statement; such as, "to prepare for life," to a comprehensive list of fifty or sixty specific objectives.

According to Cunningham, (24,608), the authors of the various lists of objectives may be classified into two

main groups.

"One group is interested in science and subject matter only, and often maintains that it does not matter what the subject matter is as long as it is science. These people point out, no one knows when the facts taught may be found to be of vital individual or social value and that it is a better demonstration of scientific procedure and of the detached attitude of the scientist to ignore in our own teaching the consideration of practical or utilitarian values.

"The other group takes the point of view that education in biology, as in all other subjects, is for the purpose of modifying or conditioning behavior; that it is to be used for the purpose of bringing about better types of reactions to situations. The group states that the objectives should be set up in terms of modification of behavior that may reasonably be expected to result from teaching; that these outcomes should be for the specific objectives set up."

(4) Criticisms of Objectives: The criticism of the aims expressed by the first group is that the public high school does not specially provide training for boys and girls to become scientists. Ninety per cent of them will take their places in the household or in industry immediately after they complete their high school courses. If the mental discipline received in mastering the subject matter is to be the important consideration, the subject matter would serve equally well if of a practical nature. Therefore, practical objectives can be emphasized without sacrificing the disciplinary objective.

The criticism of the second group arises through the difficulty of determining any tangible evidence of the attainment of attitudes, skills, or appreciations. Pupils

are rated by means of periodic tests and final examinations on their ability to recall factual information, not on their acquisition of a scientific attitude or habit of open-mindedness, or their development of an appreciation of the beauty and harmony of the universe.

Bayles, (15,1049), reporting on an investigation made in the Cleveland public schools states:

"Courses do not show that the material was taught to achieve the aims accounted for. Aims were generally filed away for reference and display to visitors. Only one teacher in the Cleveland schools made any systematic attempt to follow out the objectives laid down."

(5) Improvement of Objectives: To make these aims of practical use to the biology teacher, the three following tasks must be accomplished:

1. To relate them to the general objectives of education and demonstrate how biology makes a contribution to the development of the educated person.
2. To relate them to the subject matter in biology and show how each phase of the subject matter in biology contributes toward the general objectives of biology.
3. To determine some method of measuring achievement of these objectives and of basing promotion on this achievement.

Noll, (37,5), states:

"Definite goals are no less valuable in teaching than in other types of activity. The teacher who organizes and conducts his or her work with definite aims in mind

is readily distinguished, even by the untrained observer, from the one who attempts to teach without definite ends in view. In the teaching of science as in other fields, a clear statement of the goals of science teaching should function in the daily work of the teachers of science. It should suggest methods of procedure and bring unity and definiteness of purpose to work in this field."

It is not within the scope of this paper to make an investigation as to how each of the topics in biology may be used to develop one or more of the cardinal principles of education as proposed by the committee of the N. E. A. However, such a study should be of value to the teacher in determining the subject matter to be used and the method of presenting it.

(6) Education Objectives in New York State: In New York State a committee appointed by the Associated Academic Principals Association has proposed for the State nine "theses" as a guide to aid in determining the content of secondary education, (28,1-3):

1. "Secondary schools should provide education adapted to the needs of all boys and girls approximately between the ages of 12 and 18.
2. "Subject matter taught in secondary schools should be determined by the needs of society and by individual abilities and interests.
3. "Any given unit of subject matter varies in its value to different pupils because of differing abilities and interests.
4. "No secondary school subject can be classified as intrinsically disciplinary, cultural or vocational. Each subject has any one or all of these values as it functions in the life of the individual boy or girl.

5. "Irrespective of the pupil's length of stay in school, the subject matter should be so planned that he will recognize its value.
6. "The purpose of differentiated curriculums should not be to provide for different ability levels. Different curriculums should provide for different interests; there will be several levels of ability in each curriculum.
7. "Except for the minimum requirements set up by the State, the responsibility for the secondary school curriculums rests with the local community. These curriculums should be determined by each locality in terms of size of school, the fundamental arts and interests of the community, and the adolescent groups whose needs are to be served.
8. "A uniform standard of attainment for all secondary school boys and girls cannot be maintained. Standards should be determined for each individual on the basis of his abilities and interests within the limits of social value.
9. "Every pupil completing a secondary school curriculum adapted to his needs should receive a diploma. This diploma should specify the nature and quality of the work completed."

(7) Biology Objectives in New York State: The New York State General Biology Syllabus contains no formal list of objectives. The following statement is made in the foreword, (10,5):

"It will be noted that the objectives in this syllabus do not appear in the usual traditional form. The committee feels that the purpose of General Biology and its place in the curriculum are already set forth in the introduction and in the body of the material.

"In the introduction are found only such general statements of purpose as, 'Man as a species in relation

to his environment'. The unavoidable acceptance of evolution as the simplest explanation of similarities and diversities among living things. Promotion of the welfare of the human species through genetics...." (10,8).

Apparently the acquisition of such information as is suggested "in the body of the material" is an end in itself.

(8) Objectives in Science for Rochester Schools: The objectives for science as outlined in the Rochester City Syllabus are more in detail, although this syllabus is in reality a detailed outline of subject matter included in the State syllabus. The two different methods of stating objectives for the same course illustrate the wide difference found in the methods of stating objectives. The objectives as stated in the Rochester City Syllabus follow, (12,III):

ATTITUDES OF UNDERSTANDING

1. "Confidence in the scientific method and its findings.
2. Scientific curiosity.
3. A habit of open-mindedness.
4. Development of intellectual honesty.
5. Recognition of law of cause and effect.
6. Acquaintance with the theory of evolution as orderly change.
7. Disposition to use scientific laws for the common good.

ATTITUDES OF APPRECIATION

1. "An appreciation of great scientists in their unselfish devotion to truth and of their achievements and contributions to human welfare.
2. Permanent interests in scientific matters.
3. Sensitiveness to the beauty and harmony of the universe.
4. Appreciation of man's possibilities of improvement in the scale of life and acceptance of individual respon-

sibility for the advancement of the race.

SKILLS

1. "To use the scientific method:
 - (a) To recognize and state a problem clearly.
 - (b) To analyze a problem and devise means for its solution.
 - (c) To gather, record and interpret adequate data before generalizing.
 - (d) To reach conclusions or generalizations warranted by data.
 - (e) To test generalizations by application.
2. To observe and report accurately.
3. To use instruments of precision accurately.
4. To develop skill in representing data by means of graphs, tabulations, diagrammatic drawings, etc.
5. To develop skill in interpreting diagrammatic and graphic representations.
6. To give suitable care to laboratory apparatus.
7. To use scientific terms with clearness and accuracy.
8. To become acquainted with the reference materials of science and to develop skill in their use.

It is to be noted, first, that this list of objectives is classified into three main groups; namely, attitudes of understanding, attitudes of appreciation, and skills; second, that great emphasis is placed on the use of the scientific method; third, that no mention is made of the acquisition of information as a major aim.

(9) Objectives Applied to Biology: The writer believes that if the objectives stated in this list are to be achieved, the material to be observed must be available to the pupil and that he must be led to observe, record observations, and to reach an ultimate conclusion by all the means which an

intelligent teacher may be able to use and with a minimum of suggestion from the teacher. Since the sciences have no special monopoly on the scientific method, if biology is to make any special contribution to the education of the individual, it must be through the materials used and not through a different method of thought.

If an intelligent and appreciative attitude toward nature is to be developed, it must be through intimate contact with nature. The real opportunity is missed unless a first-hand study of nature is used at every opportunity possible. Books have an important place in the study of biology, both as sources of information and as a means of securing explanations; but beauty and harmony in nature are appreciated, not through the printed pages of a book, but through a pleasant and intimate contact with nature.

Therefore, the objectives should determine the general content of the course. Each topic should be definitely related to the aims of the course, and the teacher must have the general and specific objectives of each topic thoroughly in mind and so direct the activities of the pupils that they will be purposeful, and so that the pupil will attain the desired objectives.

(10) Summary: The objectives of biology teaching are closely related to the general objectives of education. The list of seven cardinal principles of education as stated by the committee of the N. E. A. are accepted for this discussion as the general objectives of education.

The general objectives for science used in this discussion are those stated by the Committee on the Reorgani-

zation of Science. They do not differ greatly from the objectives of general education.

Definite objectives in teaching biology are as necessary as objectives in other fields of endeavor. Biology objectives may be classified into two groups; those emphasizing the acquisition of subject matter and those emphasizing the modification of behavior.

Science and biology objectives may be made practical by relating them to the objectives of general education and to the subject matter taught. There is need for means of measuring the accomplishment toward the attainment of the objectives emphasizing the influencing of behavior.

In New York State, a committee of the Associated Academic Principals formulated nine guides to indicate the functions of general education.

The New York State Biology Syllabus contains no formal list of objectives, but includes them in the statement of the course.

The Rochester City Syllabus contains a list of objectives stated in terms of (1) Attitudes of understanding, (2) Attitudes of appreciation, (3) Skills.

To attain the objectives set up in the Rochester syllabus, biology should offer a large amount of concrete material for observation and study, and should provide abundant opportunity for pleasant and intimate contact with nature.

CHAPTER 5

METHODS USED IN TEACHING SCIENCE

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METHODS USED IN TEACHING SCIENCE

(1) Need for Methods: Sound pedagogical methods are as necessary to the purposeful teaching of science as well defined objectives. Correct methods of teaching determine not only the quickest and most effective means of achieving the desired ends, but also determine what contribution to the education of the pupil is made by the study of any particular topic. Whether the purpose in teaching is the acquisition of information or the development of specific skills or attitudes is an important consideration in determining the method to be employed.

(2) Variety in Methods: Many different methods and teaching devices are used in the teaching of science. Hunter, (31,161), says of these:

"Some are traditional and have been used ever since the monkish days of the early universities. Others have come with our greater knowledge of psychology of children and of how they learn. Some of these traditional methods savor of authority. Another series of methods uses a different type of approach. The laboratory with its individual work and the demonstration, the development of the thought process by means of Socratic questioning, the problem and project, all of these are essentially inductive or deductive methods of approach or combinations. But we are forced to believe there is no royal road to straight thinking and that even the methods which we believe have the necessary devices to insure this thinking may fall short because of the lack of the proper use of the method on the part of the teacher or understanding of its use on the part of the pupil."

There is no one best method which can be applied to

the teaching of all topics of biology or even to one topic. The personality of the teacher, the content and arrangement of the subject matter, the availability of material for demonstration, the size of the class, the time allowed for the work are all typical of factors which determine the method to be used. Therefore, any attempt to prescribe specific methods to be used in all situations would be futile. The final solution rests with the training, the good judgment and common sense of the teacher, who, recognizing the objectives to be attained, analyzes the problem in terms of existing conditions and determines methods most suitable to his needs. "Methods of teaching are, after all, simply means to ends, and the thing in which we are most interested is to find the means by which we can best attain the ends," (37,43).

(3) Lecture Method: The lecture method is not extensively used in high schools, although it is commonly employed by college professors. It is economical in time, and when used to introduce and motivate new topics, or to stimulate interest in the work of great scientists, has a useful place in teaching methods even in the high school.

The weakness of the method is that there is no means of compelling the pupil to accept the information given to him. He is neither required to actively participate in the work nor to use independent thought. His attitude is at best one of passive acceptance. He may take notes on the lecture but unless the teacher requires him to do something with the notes, they are probably left undisturbed. The lecture method for these reasons is of no great value in secondary school teaching.

(4) Textbook Method: The textbook-recitation method, in spite of the broadside of criticism which has been leveled against it in recent years, is still one of the most widely used methods in secondary schools. The results of a study made by Hunter in 1933, (20,286), who submitted a questionnaire on methods of teaching to 300 leading science teachers and to the members of the National Association for Research in Science Teaching are shown in Table VI. He found that

TABLE VI

Emphasis Placed upon Various Methods by Teachers
Throughout the Nation and by Members of
The National Association for Research in Science Teaching

Method	Teachers' Emphasis	N.A.R.S.T. Emphasis
Text	16.27%	16.79%
Reference	16.10	13.17
Laboratory	16.62	14.47
Demonstration	13.78	15.50
Discussion	18.09	17.82
Field Work	7.35	11.11
Project	8.59	7.43
Others	1.16	3.61

among both groups of teachers five methods were ranked about equal in importance; namely, textbook, reference, laboratory, demonstration, and discussion methods. Of these, the use of the textbook among both groups of teachers is ranked second in importance to the discussion method, but the difference between the two methods is so slight that it is of very little significance.

The textbook is a valuable aid to the science teacher when properly used. Its worth as a source of information to

supplement the regular laboratory work is well established. The objectionable features of the textbook method originate in the exclusive dependence upon the textbook by both pupils and teacher. It is this slavish dependence upon the book, as the sole authority, that prevents the development of a critical attitude, denies the pupil an opportunity to do his own thinking, and creates a handicap to his meeting the problems of life.

(5) Laboratory Method: The most distinctive feature of science teaching is the use of the laboratory as a means of offering pupils an opportunity of gaining information through direct observation of material studied. Laboratory work, in most cases, means that each pupil or small group of pupils is supplied specimens and such equipment as may be needed for observing or studying the specimen in order to get the desired information.

The special values attributed to this method are due, not so much to the particular quality or kind of information secured, as to the habits, attitudes, and skills developed by performing the tasks assigned. Advantages usually attributed to the laboratory method of study are:

1. Provides an opportunity to learn to do by doing.
2. Develops a scientific attitude through practice.
3. Gives training in following directions.
4. Provides a means of possible training in the experimental solution of the pupil's own problems.
5. Provides a study of objective material which is an aid to the understanding of biological terms and generalizations.

Some objectionable features to the laboratory method, especially for general biology, are cited:

1. It is more expensive than other methods because more equipment is needed.
2. It is wasteful of the pupils' time because they are unskilled in laboratory technique.
3. Skill in laboratory technique is of questionable value to the great majority of the pupils who will not enter college and, therefore, will have little use for such training.
4. There is no guarantee that the pupils will learn to solve problems or think scientifically by doing laboratory work.
5. Some studies indicate that other methods of teaching, as the demonstration method, are more productive of desired results.

The individual laboratory method, regardless of its merits or weaknesses, has been largely supplanted in many biology classes by other methods. There are several reasons for this change. During the last decade schools have been compelled to operate on reduced budgets. This has produced an increase in class size and limited the amount of laboratory equipment which could be provided. Emphasis has been placed on "Training for Democracy". Social problems have been pushed into the foreground so that a larger portion of general biology courses is devoted to this type of work which does not readily lend itself to laboratory technique. Also, there are many who argue that other methods of teaching are quite as efficient and not so costly in equipment.

(6) Teacher-demonstration Method: The demonstration is an old device, but its adoption as a principal method to take the place of individual laboratory work in science teaching is much more recent. Apparatus and materials are placed on the teacher's desk, and all of the work is done by the teacher while the pupils observe the procedure from their seats. Although this may be modified by permitting some pupils to assist with the demonstration, the majority of the class take no active part in doing the work. There is usually some discussion to establish the purpose of the demonstration or to emphasize significant observations to be made and conclusions to be drawn.

Some of the advantages claimed for this method are:

1. It is economical of time.
2. A small amount of equipment is needed.
3. Uniform results are secured in that all pupils see the same operations and the same technique.
4. It is adaptable to larger classes than the laboratory method.
5. The teacher can be sure that each pupil sees and interprets the work in the same manner.

The weakness of the method is as follows:

1. The teacher does the active work while the pupils remain the spectators.
2. Pupils are prevented from having the more intimate contact with materials, such as they would have in the laboratory method.
3. The assumption is made that all pupils are going to be equally attentive at all times, that they

all see the demonstration equally well and derive the same value from it.

4. This method tends to prevent pupils from making their own observations, doing their own thinking, and formulating their own conclusions.

Many science teachers believe that these undesirable features of the method are sufficiently objectionable to destroy its usefulness as a basic method of science teaching. Nevertheless, it is a widely used method (Table VI) in many schools and becomes very effective when used by a skillful teacher to explain scientific laws, or generalizations. It becomes of special value in demonstrating experiments which require special apparatus or expert technique in their operation.

(7) Evaluation of Methods: There is no general agreement among investigators and teachers as to a best method of teaching biology.

According to Kellman, (33,79), Downing reported that the demonstration method was as satisfactory as the laboratory method when the tests immediately followed the completion of the work, but in delayed tests, the laboratory method proved superior.

Curtis, (25,49), reports the results of Cunningham's investigation as favoring the demonstration method:

1. "The average savings of time secured by the demonstration method over the individual laboratory method was 12.2 minutes, (almost 30 per cent).
2. "Pupils can get what was done in a difficult method of procedure as well (than) or better, by doing individual laboratory work."

3. "In the lecture-demonstration experiments, the pupils made a final average upon all exercises 5 per cent higher than the final average made by those who did the individual work."

Downing, (27,497-505), enthusiastically advocates the lecture-demonstration method in connection with project teaching in biology; Hunter, (31,176), advocates a "combination period in which demonstration, discussion, and individual work are interwoven;" Coopriider, summarized by Curtis, (25,75), reports: "Demonstration work gave somewhat better results than individual work although the difference was slight."

(8) Reduced Budgets: Curtis, (26,335-360), investigating the schools of the North Central States, reported four major factors resulting from the reduced school budgets and the employment situation caused by the depression. These factors have had a pronounced affect on the methods of science teaching.

1. There has been a progressive increase in class size.
2. There has been a corresponding decrease in the amount of individual laboratory work.
3. More and more responsibility is placed on teachers for providing apparatus and material.
4. The teachers of science are of a lower standard than before the depression, and as a result, methods must be adapted to the abilities of the teachers.

This study by Curtis raises the question as to whether the introduction of the demonstration method in place of the laboratory method is a result of conditions of the

times or a result of an attempt to find the method of teaching which is best for the pupils. His claim that the standards of the teachers have been lowered in recent years is unique. The explanation, however, is that the authorities in charge of teacher placement believe that any one may teach elementary science because it deals with the familiar things of life. Therefore, many people who had never taught, and some who had taught years ago but had long since left the field of teaching, presented their old diplomas and applied for a position teaching science when other employment failed them. Just how much this may affect the methods of teaching biology is difficult to ascertain but unquestionable has had some affect.

(9) Summary of Investigations: There are many reports of investigations of the relative merits of different methods of teaching science. The results are so varied, however, that only very general statements can be used to summarize them. Investigators seem agreed on the following points:

1. Present evidence does not indicate that there is one best method of teaching biology or science adaptable to all situations.
2. The teacher-demonstration method is increasing because it saves money in the purchasing of equipment, and can be used with larger classes than the laboratory method. Just how efficient it is as compared with the laboratory method cannot be accurately stated.
3. On the basis of present evidence, neither method should be discarded. The use of the method should be determined by the particular situation

and the good judgment and common sense of the teacher.

4. Reduced school budgets and increased class sizes are factors tending to increase the use of the demonstration method.

Noll, (37,47), after making a study of twenty-three investigations concerning methods and courses, lists the following eight generalizations as indicative of the present conditions:

1. "Other things being equal, use lecture demonstrations for the more difficult and more expensive experiments.
2. "Other things being equal, use the individual laboratory experimentation method for simple, short, and less expensive experiments.
3. "Require pupils to submit brief but carefully and accurately written reports of experiments.
4. "Recommend that pupils make simple, analytic drawings rather than representative ones.
5. "Use laboratory manuals when circumstances make it necessary or highly desirable, but not for all experiments.
6. "Wherever suitable, use workbooks as motivating influences and as stimulants to pupil activity.
7. "Use visual aids.
8. "Organize materials of instruction and present them by methods that encourage the pupil to a maximum of freedom and self direction, and that permit the fullest provision for individual differences."

(10) Summary: This chapter contains a discussion of the relation of methods in science to results obtained with special references to biology.

Correct methods of teaching are an important factor in determining the purpose and accomplishment of teaching.

Methods used are varied, ranging from the old traditional to the more modern methods based on the psychology and needs of the child. No one method can be called best for all teaching situations.

The lecture method, although not extensively used in secondary schools, does serve a useful purpose in some cases. Its weakness is that it permits a passive attitude on the part of the pupils who may not be receptive to the material given.

The textbook method, although much criticized, is widely used in schools. This method has a very definite place in science teaching. The criticisms arise from its improper use, which permits both teachers and pupils to place complete and exclusive reliance upon the statements of the textbook.

The laboratory method is the most distinctive feature of science teaching. Certain special values are claimed for this method as a means of developing skills and attitudes which are not developed in other courses of study. Objections are offered to its extensive use in that it is more expensive because of the extra equipment needed, and some claim that it is wasteful of the pupils' time.

The teacher-demonstration method has displaced the laboratory method in many schools. Equally good results are claimed for this method by many teachers and investigators; it is more economical in equipment than the laboratory method.

There is no general agreement among educators,

teachers, and investigators as to the relative merits of the different methods. However, Noll has outlined eight general principles of procedure which can be used in all methods of teaching biology.

CHAPTER 6

ARRANGEMENT OF SUBJECT MATTER

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(1) Methods of Arrangement: A study of textbooks and courses of study in biology discloses two widely different arrangements of subject matter. In the first arrangement, the subject matter is centered around a study of types of plants and animals, usually arranged in a phylogenetic series. This arrangement is termed systematic arrangement in the discussion which follows. In the second arrangement, the subject matter is grouped around the life functions of plants and animals. This is known as the functional arrangement.

(2) Systematic Arrangement: Type forms as illustrations of the major groups are used in the systematic arrangement which is traditional in systematic botany and zoology. Representative specimens of the more important phyla of plants and animals are studied in turn. An understanding of taxonomy and morphology are the principal aims of the course. Habit, structure, all life functions, and economic importance are studied at one time while the specimens are before the pupils.

An example of such an arrangement is the study of flowers and fruits which has been taken from a typical course of study in biology, (6,15).

XXI "Flowers and Fruits (Organs of Reproduction)

1. "Drawings to show general structure of the parts of flowers. Function of each part.
2. "Location and cellular nature of ovules and pollen; formation of seed from fertilized ovule.
3. "Pollination and fertilization;

adaptations of a few common flowers for pollination.

4. "Drawings to show external structure and internal structure of two or more fruits.
5. "Parts of the flower present in the fruits studied.
6. "Adaptations of fruits for dispersal of seeds.
7. "Economic importance of common fruits and common plants, including weeds."

(3) Functional Arrangement: In the functional arrangement, emphasis is placed on the fundamental life functions of both plants and animals, and the relation of these to man. The importance of morphology and taxonomy is minimized. The life functions form the basis of generalizations which are immediately established by a study of numerous plants and animals.

This type of arrangement is illustrated by a unit of study taken from the present New York State Biology Syllabus, (12,11).

II "There is Unity Among All Living Things.

1. "Living things resemble each other in gross structure and function.
2. "Living things are like each other in microscopic structure and function.
3. "All living things grow by the multiplication of their cells.
4. "Resemblances between living things indicate relationship.
5. "Living species resemble fossil forms.
6. "Younger stages of living forms

resemble each other more than the adult stages.

7. "The early stage of an advanced type is often like the adult stage of a simpler species.
8. "Similar species live near each other."

(4) Comparison of Arrangements: The systematic arrangement of subject matter is more suitable to the study of concrete material than the functional arrangement. In the systematic arrangement, all facts bearing on the organism are studied at one time; therefore, the plant or animal may be brought into the laboratory and the study completed. In the functional arrangement, the study of each function involves a wide range of plants and animals. To make a laboratory study of each function necessitates a continuous display of all plants and animals studied. Such a continuous display is impracticable in a high school laboratory.

The functional arrangement presupposes a greater knowledge of plants and animals than the systematic. In the former, it is necessary to have previous knowledge of structures and functions sufficient to give meaning and content to the generalizations which are emphasized. In the systematic arrangement, knowledge of structures and functions is based on the study of concrete material but the arrangement of the material does not tend to emphasize the generalizations, and unless the purpose of the type study is clearly defined, and comparisons made with other members of the group, the generalizations are lost to the pupil. This necessitates proper guidance by a capable teacher who has the large concepts in mind as definite objectives which should be

developed.

The laboratory work, which consists of the study of structures and functions by means of direct observation in the systematic course, is changed in the functional course to "exercises" requiring the compilation of data in order to establish generalizations. In the systematic arrangement, complete and exact information is obtained by direct observation of a few type specimens. This knowledge of the type studied must be applied to other members of the same group in order to get a generalization. In the functional arrangement, less time is consumed in studying specimens, and more time given to securing information from many sources. The study centers around the generalization which is obtained from observations, discussions, textbooks, and reference books.

(5) Criticisms of Systematic Arrangement: Emphasis on laboratory work in the systematic arrangement provides opportunity for developing the skills and attitudes incidental to this type of study. The following claims are made for this work in the systematic arrangement:

1. A thorough knowledge of a limited number of plants and animals is gained by direct observation. This knowledge can be applied to others which have not been so intensively studied.
2. Practice in the use of the scientific method is given by a first-hand study of laboratory specimens.
3. Skill in the use of apparatus and laboratory technique is developed by practice in using them.
4. The learning process is augmented by providing

visual experiences beyond the concepts of words.

5. The powers of observation and judgment are developed.

Weaknesses attributed to this arrangement are:

1. Information concerning plants and animals is confined to a thorough knowledge of those studied. Others remain unknown.
2. Community problems and the relationship of these to man are not given proper emphasis.

Under the supervision of an indifferent teacher, such a course degenerates into a type study of a few specimens with no attempt to form broad concepts. The information concerning the few specimens may be obtained from a textbook rather than from laboratory work.

(6) Criticisms of Functional Arrangement: In the functional method, emphasis is placed on teaching broad generalizations with man as the center of interest. Wells, (43,158), writes of this method:

"And herein lies the essential worth of the functional method of presentation. Man is constantly in the foreground. His relations with other animals and plants are brought out in every lesson. Instead of waiting until the last part of the course to study the biology of Man, this most interesting and important phase is continually under investigation. The results claimed are: a more sustained interest throughout the course, a better understanding of the interrelationship of organisms and the perfection of nature's balance, as well as a more complete realization of the vastness and complexity of the living world."

Likewise, this arrangement has its disadvantages,

which are:

1. The pupil has little opportunity to gain first-hand knowledge upon which to base his generalizations. For those pupils who do not already possess a fund of information concerning plants and animals, the generalizations are meaningless.
2. The pupil is taught to place complete reliance on books for information, since a large percentage of the subject matter is taken from books.
3. The pupil accepts the generalization from the textbook before he acquires the information upon which it is based. Thus, he is denied the opportunity of doing his own thinking.

When this method is used by the incompetent teacher, no effort is made to give any content to the generalizations beyond the printed word. So-called laboratory work consists of copying tables, charts, and diagrams, and outlining information taken directly from the textbook. Hunter, (31,VII), states, "Too often has a laboratory exercise meant nothing to a pupil but "busy work"." The subject is reduced to a verbal knowledge of generalizations, which is useful in passing teachers' tests and final examinations, but develops no ability to apply these generalizations to life situations or problems in nature.

The writer is convinced that a combination of these two methods can be so organized that the most desirable features of each are contained in one general plan. Wells,

(43,159), states concerning this possibility:

"Then why not teach by both methods? Why not apply what seems best in each? If it is true that students come into the biology classroom without the structural background necessary to an understanding of functions, why not give them the foundation; early in the course? Is it not reasonable to assume that a student will more readily grasp the broader concept of respiration, if he knows the general structure and locations of stomata, lenticels, gills, spiracles, and lungs in the various forms than if he has to stop this assimilative process to ferret out each in turn? Several years of observation and experiment have convinced the author of the soundness of this theory. We have taught classes according to the purely functional life process method and we have taught classes according to the systematic, structural viewpoint. We have combined the two in practice. It has been our observation, over an extended period, that all groups, whether segregated according to sex, or intelligence quotient, or mixed without regard to either, react best to a systematic structural foundation leading to the study of functions, processes, and principles. The author is convinced that this combination method excels either of the others in creating a foundation for conclusive scientific reasoning and developing a well-balanced attitude toward biological theory and fact."

(7) Summary: Two widely different arrangements of subject matter are found in biology courses. These are the systematic arrangement and the functional arrangement.

In the systematic arrangement, representative types of plants and animals are studied. Emphasis is placed on morphology and taxonomy.

In the functional arrangement, topics are organized in units, each one of which emphasizes a broad general concept.

The systematic arrangement of subject matter pre-

sents greater opportunity for the study of objective material in the laboratory than the functional arrangement.

The functional arrangement provides opportunity for a wider range of study than the systematic, but less emphasis is placed on the objective study of specific material.

Skills and attitudes incidental to laboratory study are developed in the systematic arrangement. Due to indifferent teaching, this knowledge of plants and animals may be confined to those studied in the laboratory.

Advantages claimed for the functional arrangement are sustained interest and a better understanding of the complex biological laws of nature. However, the information obtained through this arrangement is obtained from books, and may be superficial.

The systematic and the functional arrangements may be so combined that the desirable features of each are used and the objectionable features omitted.

CHAPTER 7

ANALYSIS OF THE COURSE OF STUDY

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(1) Pupil Ability: This course of study in biology has been prepared for use in the "slow" classes of the Benjamin Franklin High School at Rochester, N. Y. While selecting the subject matter to be incorporated in the course, serious consideration has been given to the needs of these pupils, their interests, abilities, attitudes, educational background, and probable future occupations.

The following characteristics are to be noted concerning these pupils: They are in the tenth and eleventh years of school and vary in age from fifteen to eighteen years. Fifty per cent of them have parents of foreign birth and many of these parents neither speak nor understand the English language. The remainder of the pupils have American parents who are laboring people, living in modest homes. None of these pupils come from homes of wealth, many come from indigent families. They are primarily interested in earning a living and are accordingly registered in the vocational courses.

These pupils have had no scientific training in nature study previous to entering the class in biology. They have had general science in the seventh, eighth, and ninth grades, but this work has dealt almost entirely with subject matter taken from the physics and chemistry courses. They have a very slight knowledge concerning plants and animals, and related problems in nature.

It is necessary, therefore, in order to form general concepts, to begin with the simple studies concerning their immediate environment and those things with which they are at least partially familiar, and to proceed from these to the more difficult problems. It is necessary to develop factual information from an objective study of concrete material in order to build concepts.

(2) Objective Study: Special emphasis has been placed on the use of objective material in this course because the majority of the pupils have a very limited vocabulary and are accordingly handicapped in reading ability. The mere acquisition of facts is not the main objective in this study of concrete materials. The attainment of attitudes of understanding, of powers of observation and independent thinking, the formation of percepts and the organization of these into broad concepts are of greater importance.

(3) Objectives: Definite objectives are necessary in the preparation of any course of study. The objectives of this course are those of the Rochester City Syllabus and are stated in Chapter 4.

(4) Unit I: It is intended to suggest in this unit an abundance of subject matter so that the teacher and pupils may be free to select that which is most available and suitable to their needs. It is not intended that any one class should cover all of the work suggested. To do this would entirely destroy the purpose of the unit.

To suggest the exact number of specific plants and animals which a class must study would also defeat the purpose of the unit, because then, some few plants and animals would

be set up as types, upon which the class must concentrate its attention and know thoroughly. Such a plan might furnish the teacher with a yardstick for measuring work accomplished, since, when a definite number of plants and animals had been learned, the unit would be completed and could be considered closed insofar as further study is concerned. This, however, is not the spirit of biology. Only the expert in a very limited field would dare to admit that he knows his field thoroughly.

The purpose of this unit is, rather, to open the field of biology to view, to arouse a spirit of curiosity and inquiry among the pupils, with the understanding that this spirit of inquiry cannot be satisfied with a simple knowledge of descriptive names and a few facts learned from textbooks. The whole field of biology should be thrown open to preview. The evident struggle for existence, adaptation to environment, methods of securing food, life and reproduction of insects, seed dispersal of plants, and the relationship of these to man are but a few of the subjects which should suggest questions that would require the remainder of the year or more to answer.

Field trips are especially desirable. Also, much material may be brought into the laboratory by the pupils. Herbarium specimens and insect collections will be valuable aids for later study although it should be understood that these are not ends in themselves, but serve as a means of providing concrete material for observation when fresh specimens are not at hand. Incidentally, they may also suggest to some pupils interesting hobbies which may be carried on

through the remainder of their lives. Pictures or films will also be of great service in extending the range of study to more distant and less familiar environments.

The teacher must be familiar with the general biologic concepts that follow, and with these in mind, be ready at all times to direct inquiry in a direction which will lead to the establishment of such concepts. The unit is not intended as a random study without aim or direction. Each day's observations should be purposeful and directed toward developing the important biological concepts which follow.

It should provide a pleasant and agreeable opening of the subject to both pupils and teacher, and should leave the pupil with the understanding that there are many questions as yet, unanswered, that the big task for the remainder of the year is to find the answers to as many as he can.

(5) Units II and III: In units II and II emphasis should be placed on the laboratory study of plants and animals in order to provide opportunity for these pupils to form more than verbal concepts of material studied. The textbook should be used to supplement the work of the laboratory rather than the laboratory work used to supplement the textbook. Pupils should be required to make accurate observations and use a scientific attitude in the execution of each laboratory task.

The teacher should keep in mind the large concepts which are to be developed. Thus, the cellular structure of simple plants furnishes the basis for understanding the cellular structure of all plants and animals. Chlorophyll in the cells of green plants not only produces starch and sugar for the plant, but furnishes food for all living things in

the world. The need for means of locomotion in the paramecium, grasshopper or earthworm, in order to secure food, supplies objective evidence that all animals need means of locomotion, for unlike green plants, they are unable to manufacture the food which they need. Thus, each laboratory experiment should furnish a mental percept which will aid in the formation of broad concepts or generalizations.

If the aim in teaching this material is merely the accumulation of a large number of detailed and unrelated facts concerning the structures and functions of plants and animals, the purpose of the unit is lost. If, however, the teacher presents the facts as parts of broad general concepts, which he is aiming to develop, and which should be developed in order that biology may function as a practical and useful subject, such work presents an opportunity to secure the much needed understanding on which the concepts are based. The value of these units depends upon the ability of the teacher to present this work in such a manner that these large concepts are the ultimate conclusions reached by the pupils as a result of their own observations and the work which they have accomplished in the laboratory.

(6) Unit IV: The biology of man is not adapted, in high school classes, to the same kind of laboratory study as the biology of plants and animals, but does present opportunity for using the knowledge which has already been gained in the preceding units. The teacher should use this occasion to review and apply those general concepts which have been developed in the study of plants and animals. For example, the study of the sense organs of man, and their function in

enabling him to become aware of stimuli, should be related to the concepts previously developed that both plants and animals have adaptations for responding to certain stimuli. Likewise, the food used by man should suggest its source and the means by which it is produced, and the importance of chlorophyll in this process. In the same manner, each of the other topics of Unit IV may be related to general concepts already established.

(7) Unit V: Unit V, which is concerned with asexual and sexual reproduction, contains more material for study than can be used in "slow" classes. The amount of subject matter studied in this unit will, of necessity, be determined by the good judgment of the teacher, and the abilities and interests of the pupils. Probably it will be necessary to omit much of the more complex and difficult material in all "slow" classes.

Elementary information concerning the asexual and sexual reproduction of plants and animals has been outlined in Units I, II, and III. Therefore, the first part of Unit V is a review of the relative subject matter from these Units.

Emphasis should be placed on the practical phases of asexual reproduction which is more concerned with the pupils' immediate interests. The uses and advantages of vegetative propagation of fruit trees, ornamental trees, shrubs, and greenhouse plants is of practical value to these pupils who do not expect to enter college.

In the study of sexual reproduction, only a sufficient amount of time should be given to insure an understanding of the elementary laws of heredity. More material has been included in this topic than most classes can be expected to complete. However, some pupils who are

particularly interested in this subject may be able to complete the work as outlined. The amount of work assigned must be left to the discretion of the teacher, and the interest and abilities of the pupils.

(8) Unit VI: Unit VI is a summary of the general concepts and basic biological principles which have been gradually evolved in Units I, II, and III, expanded to include the biology of man in Unit IV, and reproduction in Unit V. The study of these principles should, in each case, include a review of the basic information upon which they are founded.

(9) Unit VII: Unit VII is concerned with the origin and evolution of man. The study of his origin and his gradual progress through the stages of empirical thinking to the modern science of today is an appropriate climax to the study of general biology.

The inclusion of the study of man in the last unit does not mean that the relationship of man to the plants and animals of his environment should be neglected in previous units. Man's dependence on plants and animals for food, clothing, and shelter has already been established in the previous units, if they are properly taught. To show the gradual progress made by man in the control of his environment through the domestication of plants and animals, the adaptation of the forces of nature to his own advantage, and his struggle against famine, pestilence, and disease are the major objectives of the unit.

Classification of plants and animals is placed last because this is one phase in man's control of plants and animals. This is the logical sequence. Pupils at this

time have some definite information upon which to base classification.

(10) Problems for Further Study: The writer anticipates using this course of study in the Benjamin Franklin High School at Rochester, N. Y. It is an experimental course prepared for special groups of "slow" pupils, and is subject to revision as weaknesses or desirable changes may become evident when it is in use.

More material has been included in the course than can be completed by any class of "slow" pupils. This material has been purposely included in order to permit selection by the teacher of that which is most suitable for class needs. Only actual use of the course during a period of several years will determine just how much of the subject matter should be excluded or rejected. It is expected that the course will be improved by substitutions, omissions, and additions as the needs for these become evident through its use.

(11) Summary: The subject matter of this course of study has been selected and arranged for special classes of low ability pupils of the Benjamin Franklin High School at Rochester, N. Y. Many of these pupils are of foreign parentage.

The pupils for whom the course is prepared are in the tenth and eleventh years of school, have had very little nature study work, and are generally registered as vocational pupils.

Special emphasis has been placed on laboratory work and the use of objective material to develop an understanding of the general biological principles.

The objectives of the course of study are the

objectives stated in the Rochester City Syllabus in Biology.

More subject matter has been included in the course than can be used in slow classes. This has been done in order to permit the selection of material most suitable for class needs.

The first unit consists of a survey of plants and animals for the purpose of creating interest in biological problems and permitting the pupils to become acquainted with a large number of plants and animals. Herbariums and insect collections are to be encouraged for those pupils who show a special interest in this type of work.

Units II and III include the biology of plants and animals. Laboratory work is stressed in these units in order to get first-hand information for the development of general biological concepts.

The biology of man is included in Unit IV. This work should be closely correlated with the biology of plants and animals studied in the preceding units.

Unit V deals with asexual and sexual reproduction and the development of the laws of heredity. Emphasis should be placed on the practical phases of this study since these pupils do not intend to continue their education in college.

In Unit VI emphasis is placed on the general biological concepts or the conclusions which the pupils should have reached in the study of preceding units. These principles are enumerated in order that the pupils' attention may be focused upon them.

The origin and evolution of man is the subject of Unit VII. Man's development and progress in increasing the

control of his environment climax the study of biology.

CHAPTER 8

SUMMARY

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SUMMARY

(1) Problem: The problem is to prepare a course in biology, which is suitable for use in tenth grade classes of pupils of low ability in the Benjamin Franklin High School at Rochester, N. Y.

(2) Purpose of the Course: The course is designed to:

1. Provide a course of study which will overcome the objections to the present course.
2. Stimulate interest and arouse curiosity concerning biological phenomena.
3. Provide opportunity for objective study through laboratory work in order that biological concepts may be based on understanding.
4. Place emphasis on the study of familiar plants and animals before proceeding to the unfamiliar

(3) Development of Biology: A gradual increase in the enrollment in biology has taken place in the American high schools. There has been a gradual development of the subject matter.

1. Biology has gradually displaced the older subjects, botany, zoology, and physiology in the high schools of the United States, and has become the leading biological science.
2. New York State introduced the study of Elementary Biology as a ninth year subject about 1900.
3. In 1931, a new course of study in General Biology was introduced in the New York State high schools

as a tenth year subject.

4. The course in Elementary Biology in the New York State high schools was formed by combining the older courses, botany, zoology, and physiology into one course.
5. The proposed course in biology is arranged in units of study, each one of which is based on a general concept concerned with plants, animals, and man.

(4) Objectives: The objectives of biology are closely related to the general objectives of education, and must be related to the subject matter of biology in order to make them of practical use to the biology teacher.

1. The general objectives of education used in the preparation of this course of study are the Seven Cardinal Principles of Education, formulated by the committee of the N. E. A.
2. The objectives for biology are those stated in the Rochester City Syllabus in biology. These are given in Chapter 4.

(5) Methods of Teaching Biology: Four methods of teaching biology are discussed. They are: the lecture method, the textbook method, the laboratory method, and the teacher-demonstration method.

1. The lecture method is not extensively used in high schools. It has little value except in special cases, because it permits a passive attitude on the part of the pupils, and is not efficient.

2. The textbook method is widely used, and has certain definite values although it is severely criticized by many teachers. Criticisms of the textbook method, however, result from both teachers and pupils placing complete reliance upon the textbook and failing to develop a critical attitude.
3. The individual laboratory method has advantages in supplying the pupil with first-hand information concerning plants and animals, and developing scientific attitudes and independent habits of study and experimentation. It may be wasteful of pupils' time, and requires a greater outlay for equipment than the demonstration method.
4. The teacher-demonstration method is economical in both time and materials. Investigators do not entirely agree on the relative merits of this method as compared with the laboratory method.

(6) Arrangement of Subject Matter: Two methods of arrangement of subject matter are used in biology courses; namely, the systematic arrangement and the functional arrangement.

1. In the systematic arrangement, the subject matter is separated into topics dealing with type specimens usually arranged in a phylogenetic series. This arrangement was taken over from systematic botany and zoology, and provides

- opportunity for individual laboratory work.
2. In the functional arrangement, the subject matter is divided into units, each one of which deals with a biological generalization as it applies to a large number of plants and animals. Less opportunity occurs for a laboratory study of specimens.
 3. In the proposed course of study, the writer has endeavored to combine the two methods of arrangement in order to use the best of each and omit the weaknesses of each.

(7) Course of Study: The proposed course of study is divided into seven units.

1. A survey study of plants and animals comprises the work of Unit I. The purpose is to show the pupil a preview of the biological field and stimulate interest in this field of study.
2. The study of plants and animals is outlined in Units II and III. Laboratory work is emphasized.
3. In Unit IV, the biology of man is outlined. The general concepts formed in the preceding units should be recalled and applied in this unit.
4. The study of reproduction in plants and animals is combined in Unit V. This forms the basis for the study of the laws of heredity.
5. General biological concepts are reviewed in Unit VI. These should result from the percepts formed in the study outlined in previous units.
6. The study of the origin and evolution of man

completes the study of biology in Unit VII.

His progress in increasing the control of his environment through a greater knowledge of plants and animals leads finally to the classification of plants and animals.

UNIT I

SURVEY OF PLANTS AND ANIMALS

UNIT I

SURVEY OF PLANTS AND ANIMALS

Purpose of Unit: The purpose of Unit I is to make a general survey of plants and animals in order to:

1. Acquaint the pupil with many forms of plants and animals, particularly those of his local environment.
 2. Study the relationship of these plants and animals to man and to other plants and animals in this environment.
 3. Supply a fund of information for the study of biologic principles.
1. Study twenty plants from the list below using the following outline:
 - a. Structures for recognition
 - b. Frequency of occurrence
 - c. Habitat
 - d. Flowers and fruits
 - e. Distribution of seeds
 - f. Relation to man and other plants and animals
 - g. Herbarium specimen

The following lists of plants and animals are suggested. Other plants or animals should be substituted or added as conditions permit or the interest of the class demand.

- | | |
|-------------------|-------------------------|
| 1. Asters (wild | 9. Crab-grass |
| 2. Bindweed | 10. Daisy |
| 3. Burdock | 11. Dandelion |
| 4. Buttercup | 12. Devil's paint brush |
| 5. Canada thistle | 13. Dock |
| 6. Chicory | 14. Ferns |
| 7. Chickweed | 15. Golden rod |
| 8. Clover | 16. Lamb's quarters |

- | | |
|-----------------|-----------------------|
| 17. Liverwort | 24. Quackgrass |
| 18. Milkweed | 25. Queen Anne's lace |
| 19. Moss | 26. Ragweed |
| 20. Mustard | 27. Shepherd's purse |
| 21. Peppergrass | 28. Sticktight |
| 22. Plantain | 29. Timothy |
| 23. Purslane | 30. Yarrow |

2. Study ten trees from the suggested list using the following outline:

a. Structures for recognition

- (1) Size
- (2) Shape
- (3) Leaf
- (4) Bark, color and texture
- (5) Branches, opposite or alternate

b. Frequency of occurrence

c. Use to man

d. Herbarium specimen

- | | |
|-------------------|--------------|
| 1. Apple | 11. Juniper |
| 2. Beech | 12. Linden |
| 3. Birch | 13. Magnolia |
| 4. Butternut | 14. Maple |
| 5. Cherry | 15. Oak |
| 6. Chestnut | 16. Pine |
| 7. Elm | 17. Poplar |
| 8. Hickory | 18. Spruce |
| 9. Honey locust | 19. Walnut |
| 10. Horsechestnut | 20. Willow |

3. Select five shrubs from the suggested list and proceed as with trees in the preceding exercise.

- | | |
|-------------------|--------------------|
| 1. Azalea | 11. Kolkwitzia |
| 2. Barbary | 12. Lilac |
| 3. Butterfly bush | 13. Mock orange |
| 4. Cotoneaster | 14. Privet |
| 5. Deutzia | 15. Rose |
| 6. Euonymus | 16. Rose of Sharon |
| 7. Forsythia | 17. Snowberry |
| 8. Honeysuckle | 18. Spirea |
| 9. Hydrangea | 19. Viburnum |
| 10. Kerria | 20. Weigela |

4. Collect aquatic plants. Determine their general characteristics and adaptations for life in the water.

- | | |
|-----------------|-----------------|
| 1. Duckweed | 5. Pleurococcus |
| 2. Elodea | 6. Pond lily |
| 3. Nitella | 7. Spirogyra |
| 4. Oscillatoria | 8. Vaucheria |

5. Collect or culture in the laboratory specimens of fungi from the suggested list and study, using the following outline:

- a. Color (lack of chlorophyll)
- b. Source of food
 - (1) Parasitic
 - (2) Saprophytic
- c. Method of distribution
- d. Relation to man and other plants and animals

1. Bread mold
 2. Mildew
 3. Mushroom
 4. Penicillium
 5. Rust
 6. Shelving fungus
 7. Smut
 8. Yeast
6. Collect specimens of lichens and study
- a. Habitat
 - b. Color
 - c. Structure
 - (1) Alga
 - (2) Fungus
 - d. Source of food
 - e. Relation to man and other animals and plants
7. Study ten birds from the suggested list using the following outline:
- a. Structures for recognition
 - b. Frequency of occurrence
 - c. Location of nests
 - d. Food
 - e. Migration
 - f. Relationship to man and other animals and plants
1. Blackbird
 2. Bluebird
 3. Blue jay
 4. Bobolink
 5. Catbird
 6. Chickadee
 7. Crow
 8. Duck
 9. Goldfinch
 10. Gull

- | | |
|-----------------|----------------|
| 11. Hawk | 18. Robin |
| 12. Heron | 19. Sparrow |
| 13. Meadow lark | 20. Starling |
| 14. Oriole | 21. Swallow |
| 15. Ostrich | 22. Vireo |
| 16. Owl | 23. Woodpecker |
| 17. Pheasant | 24. Wren |

8. Study ten mammals from the suggested list using the following outline:
- a. Structures for recognition
 - b. Frequency of occurrence
 - c. Homes
 - d. Food
 - e. Relationship to man and other animals and plants
- | | |
|-------------|---------------|
| 1. Anteater | 13. Muskrat |
| 2. Bat | 14. Otter |
| 3. Beaver | 15. Porcupine |
| 4. Buffalo | 16. Rabbit |
| 5. Cat | 17. Raccoon |
| 6. Chipmunk | 18. Rat |
| 7. Deer | 19. Skunk |
| 8. Dog | 20. Squirrel |
| 9. Fox | 21. Weasel |
| 10. Mink | 22. Whale |
| 11. Mole | 23. Woodchuck |
| 12. Mouse | |

9. Study ten insects from the suggested list, using the following outline:

a. Structures for recognition

b. Life history

(1) Eggs

(2) Larva

(3) Pupa

(4) Adult

c. Food

d. Relation to man and other animals and plants

1. Ant

14. Gypsy moth

2. Aphid

15. Honey bee

3. Army worm

16. Japanese beetle

4. Bumble bee

17. Katydid

5. Cabbage butterfly

18. Ladybird beetle

6. Cacrophia moth

19. Lunar moth

7. Clothes moth

20. Monarch butterfly

8. Cotton boll wevil

21. Promethea moth

9. Cricket

22. Squash bug

10. Croton bug

23. Swallow-tail butterfly

11. Dragon fly

24. Tent caterpillar

12. European corn borer

25. Tussock moth

13. Grasshopper

26. Wasp

10. Study animals from the suggested list, using the following outline:

a. Structures for recognition

b. Homes

c. Food

d. Relation to man and other animals and plants

11. Study examples of parasites of plants and animals using the following outline:
 - a. Habitat
 - b. Food
 - c. Relation to animals, more especially to man.
 1. Bacteria
 2. Bot fly
 3. Flea
 4. Hookworm
 5. Housefly
 6. Parasites of insects
 7. Intestinal worms in animals
 8. Lice
 9. Mosquito
 10. Protozoans
 11. Tapeworm
12. The earth is teeming with life which may be divided into two classes:
 - a. Plants
 - b. Animals
13. There is a constant struggle for existence among plants and animals in order to:
 - a. Secure space in which to live
 - b. Secure light, heat and moisture
 - c. Secure food and oxygen
 - d. Protect themselves
 - e. Reproduce their kind
14. Plants and animals have special structures which enable them to carry on life processes:
 - a. Respiration
 - b. Transpiration
 - c. Nutrition
 - d. Excretion
 - e. Circulation
 - f. Protection
 - g. Reproduction

15. Balance in nature results from this struggle of plants and animals for life. This balance may be upset by a change in environment.
16. Plants and animals have a distinct bearing on man's welfare.
 - a. Beneficial. They furnish material for:
 - (1) Food
 - (2) Clothing
 - (3) Wood for homes, tools, furniture and machinery
 - (4) Paper
 - (5) Fuel as wood, coal, and coke
 - (6) Medicine, dyes, extracts, and flavors
 - (7) Innumerable uses not mentioned here
 - b. Detrimental
 - (1) Crowd out useful plants
 - (2) Parasites destroy valuable food plants
 - (3) Produce disease in man and animals

UNIT II

STRUCTURES AND FUNCTIONS OF PLANTS

UNIT II

STRUCTURES AND FUNCTIONS OF PLANTS

Purpose of Unit: The purpose of this unit is to study the cells, tissues, and organs of plants and the functions of these, and to show the relation of these to man.

Since the needs of plants and animals are similar, plants have been chosen as types because of the ease with which laboratory material may be supplied.

General Study of Major Parts

A. The major parts of a plant are:

1. Roots
2. Stem
3. Leaves
4. Flowers
5. Fruits and seeds

Detailed Study

B. Root

1. Classified according to arrangement
 - a. Primary
 - b. Secondary and others
 - c. Adventitious
2. Classified according to structure
 - a. Fibrous roots
 - b. Tap root
3. Structure of a large tap root as that of a carrot
 - a. Epidermis
 - b. Cortex
 - c. Central cylinder
 - d. Fibrovascular bundles
4. Cellular structure of a small growing root as that of timothy
 - a. Root cap
 - b. Growing area
 - (1) Cells forming new cells
 - (2) Cells growing
 - c. Root hairs
5. Functions of roots
 - a. Anchorage
 - (1) Soil roots
 - (2) Adventitious roots
 - b. Osmosis through root hairs to secure soil water and dissolved minerals
 - c. Food storage

- d. Transportation through fibrovascular bundles of:
 - (1) Soil water up to the stem
 - (2) Dissolved food to different parts of the root
- e. Vegetative reproduction

- 6. Economic importance of roots to man
 - a. Provide food
 - b. Prevent soil erosion
 - c. Produce organic material to enrich the soil

C. Stem structure and function

1. Monocotyledons - corn stem as type

- a. External structures and uses
 - (1) Node
 - Leaf scar
 - Fibrovascular bundles
 - (2) Internode
 - (3) Bud
 - (4) Branching, ear and flower stalks
 - (5) Leaf sheath
- b. Internal layers and uses
 - (1) Epidermis
 - (2) Pith
 - (3) Fibrovascular bundles

2. Dicotyledons

- a. External structures and uses
 - (1) Bark
 - (2) Branching
 - Opposite
 - Alternate
 - (3) Nodes
 - (4) Internodes
 - (5) Leaf scars
 - Fibrovascular bundles
 - (6) Lenticels
- b. Internal structures and uses
 - (1) Bark
 - Dead
 - Living
 - (2) Cambium
 - (3) Wood
 - Spring
 - Summer
 - Annual Rings
 - (4) Pith
 - (5) Medullary rays
 - (6) Fibrovascular bundles

3. Modified stems

- a. Runners
- b. Stolon
- c. Bulb
- d. Leaf stem (cactus)
- e. Underground stem
 - (1) Tuber
 - (2) Rhizome

4. Main functions
 - a. Support for sunlight
 - b. Transportation
 - (1) Soil water up
 - (2) Manufactured, dissolved food down
 - c. Storage of food
 - d. Manufacture of food
 - e. Transpiration
 - f. Respiration
 - g. Reproduction

5. Economic importance of stems to man
 - a. Food
 - b. Wood
 - c. Naval supplies
 - d. Tannin
 - e. Cellulose
 - f. Dyes

D. Leaf, structures and functions

1. Arrangement
 - a. Alternate
 - b. Opposite
 - c. Mosaics
2. Parts
 - a. Petiole
 - b. Blade
 - c. Stipule
 - d. Veins of fibrovascular bundles
3. Divisions of the blade
 - a. Simple
 - b. Compound
 - (1) Palmate
 - (2) Pinnate
4. Veins
 - a. Parallel veined - monocotyledons
 - b. Netted veined - dicotyledons
 - (1) Palmate
 - (2) Pinnate
5. Internal structures and functions of the following:
 - a. Epidermis
 - b. Palisade layer
 - c. Spongy layer
 - d. Veins - fibrovascular bundles
 - e. Stomates
 - f. Chlorophyll
6. Five main conditions necessary for photosynthesis
 - a. Sunlight in a living cell
 - b. Chlorophyll
 - c. Proper temperatures

- d. Moisture
 - e. Necessary elements
7. Transpiration
 - a. Amount
 - b. Relation to moisture in soil and atmosphere
 - c. Relation to temperature
 - d. Relation to propagation
 - (1) Transplanting
 - (2) Cuttings
 8. Accumulation of mineral matter in the leaf
 - a. Source
 - b. Method of excretion
 9. Respiration
 - a. Stomates and their operation
 - b. Gas entering the leaf
 - c. Gas given off by the leaf
 10. Movements of the leaf as affected by:
 - a. Light
 - b. Moisture
 - c. Contact
 11. Economic importance of leaves to man
 - a. Food for man
 - b. Food for animals
 - c. Enrichment of soil
 - d. Medicines, flavors, extracts
 - e. Fiber
 - f. Beauty and shade

E. Flower

1. Structures and functions
 - a. Peduncle
 - b. Receptacle
 - c. Calyx - sepals
 - d. Carolla - petals
 - e. Stamen
 - (1) Filament
 - (2) Anther
 - f. Pistil
 - (1) Style
 - (2) Stigma
 - (3) Ovary - ovules
2. Reproduction in flowering plants
 - a. Production of pollen
 - b. Production of ovules
 - c. Pollination
 - (1) Self
 - (2) Cross
 - (a) Insects
 - (b) Wind
 - (c) Water

- d. Fertilization
 - (1) Pollen tube
 - (2) Union of male cell and female cell
 - (3) Formation of embryo and endosperm
 - e. Seed and its formation
 - f. Fruit and its formation
 - (1) Fleshy fruits
 - (2) Dry fruits
3. Seed dispersal
- a. Agents of dispersal
 - (1) Wind
 - (2) Water
 - (3) Animals
 - (4) Fruits
 - b. Seed structures
 - (1) Wings
 - (2) Pappus
 - (3) Hooks
 - (4) Spines
 - (5) Sticky covering
 - (6) Food content
4. Seed structures (optional)
- a. Monocotyledons - corn as type
 - (1) Epidermis
 - (2) Embryo
 - (3) Endosperm
 - b. Dicotyledons
 - (1) Testa
 - (2) Hilum
 - (3) Micropyle
 - (4) Embryo
 - (a) Cotyledons
 - (b) Leaf
 - (c) Stem
 - (d) Root
5. Review previous work correlating the number of cotyledons with the corresponding types of stems and leaves.
- a. Monocotyledons
 - b. Dicotyledons
6. Seed germination
- a. Conditions necessary
 - (1) Proper temperature
 - (2) Moisture
 - (3) Oxygen
 - b. Development of temporary leaves
 - c. Development of root system
7. Economic importance of seeds and fruits to man
- a. Food for man
 - b. Food for animals
 - c. Medicines

- d. Fats and oils
 - e. Dyes, flavors, extracts
 - f. Reproduction of desirable plants
 - g. Innumerable other uses
8. Reproduction in lower plants
- a. Ferns
 - (1) Occurrence of sori on the leaves
 - (2) Spores - occurrence and dispersal (optional)
 - (3) Germination and growth of spores
 - (a) Prothallium
 - (b) Antheridia produce sperm cells
 - (c) Archegonia produce egg cells
 - (d) Fertilization of egg cell
 - (e) Sporophyte
 - b. Mosses
 - 1. Spore capsules
 - 2. Spore dispersal (Optional)
 - 3. Gametophyte
 - 4. Antheridia produce sperm cells
 - 5. Archegonia produce egg cells
 - 6. Fertilization of egg cell
 - 7. Sporophyte
 - c. Fungi and algae
 - (1) Reproduction by spores
 - (2) Reproduction by division

UNIT III

STRUCTURES AND FUNCTIONS OF ANIMALS

UNIT III

STRUCTURES AND FUNCTIONS OF ANIMALS

A. Protozoa

I. Amoeba

1. Occurrence
 - a. Distribution
 - b. Habitat
2. Size and shape
3. Structure

a. Single cell	e. Cell membrane
b. Protoplasm	f. Food vacuole
c. Nucleus	g. Contractile vacuole
d. Pseudopod	
4. Adaptations
 - a. Sensitivity
 - b. Locomotion
 - c. Reproduction
 - d. Protection
5. Review bacteria

II. Paramecium

- * 1. Occurrence
 - a. Distribution
 - b. Habitat
2. Size and shape
3. Structure

a. Single cell	e. Oral groove
b. Protoplasm	f. Food vacuole
c. Nucleus	g. Contractile vacuole
d. Cilia	
4. Adaptations
 - a. Sensitivity
 - b. Locomotion
 - c. Reproduction
 - (1) Asexual
 - (2) Sexual
 - d. Protection
5. Structures of the paramecium showing increasing specialization over the amoeba
 - a. Fixed shape
 - b. Cilia for rapid locomotion and food getting

- c. Definite mouth region
- d. Definite excretory region
- e. Sexual reproduction

III. Euglena (Optional)

- 1. Occurrence
 - a. Distribution
 - b. Habitat
- 2. Size and Shape
- 3. Structures and functions
 - a. Flagella
 - b. Eye spot
 - c. Mouth
 - d. Chloroplasts

IV. Colonial protozoa (Optional)

- 1. Animals for study
 - a. Gonium
 - b. Pandorina
 - c. Volvox
- 2. Colonies of independent cells
- 3. Advantages of colonial forms
 - a. Locomotion
 - b. Protection
 - c. Reproduction

V. Economic importance of protozoans

- 1. Food for other animals
- 2. Scavengers
- 3. Cause of disease
 - a. Malaria
 - b. Amoebic dysentery
 - c. Syphilis
 - d. Texas cattle fever

B. Metazoa

I. Hydra

- 1. Occurrence
 - a. Distribution
 - b. Habitat
- 2. Size and shape
- 3. Structure of body as a whole
 - a. Hollow body cavity
 - b. Two layers of cells
 - (1) Ectoderm
 - (2) Endoderm

- c. Tentacles with stinging cells
- 4. Adaptations
 - a. Sensitivity
 - b. Nutrition
 - (1) Tentacles with stinging cells to secure food
 - (2) Mouth receives food
 - (3) Body cavity for digestion
 - c. Excretion from:
 - (1) Cells
 - (2) Body cavity
 - d. Respiration - cells and cell membrane
 - e. Circulation - dissolved food from inner cells to outer layer of cells
 - f. Locomotion
 - (1) Basal disk
 - (2) Tentacles
 - g. Reproduction
 - (1) Budding
 - (2) Eggs and sperm
- 5. Increased specialization of structure and division of labor.
 - a. Many cells forming tissues
 - b. Tissues form body structure
 - c. Specialized cells and tissues
 - (1) Inner cells for digestion
 - (2) Stinging cells to secure food
 - (3) Tentacles for grasping food
 - (4) Outer layer of cells for motion
- 6. Related animals
 - a. Coral
 - b. Jelly fish
 - c. Portuguese Man-of-War
- 7. Economic importance
 - a. Food for other animals
 - b. Land formation (coral)

II. Earthworm

- 1. Occurrence
 - a. Distribution
 - b. Habitat
- 2. Structure of body as a whole
 - a. Texture and color
 - b. Anterior and posterior ends
 - c. Dorsal and ventral sides
 - d. Mouth
 - e. Segments
 - f. Girdle
 - g. Setae

3. Internal structure
 - a. Covering of moist skin
 - b. Digestive system
 - c. Circulatory system
 - d. Excretory system
 - e. Nervous system
4. Adaptations
 - a. Sensitivity
 - b. Locomotion
 - c. Respiration
 - d. Feeding
 - e. Reproduction
5. Increasing specialization and division of labor
 - a. Digestive tube within the body cavity
 - b. Mouth and anal opening to digestive tube
 - c. Nervous system
 - d. Circulatory system
 - e. Muscle system
6. Other Worms
 - a. Flat worms
 - (1) Tape worm
 - (2) Planaria
 - (3) Liver fluke
 - b. Round worms
 - (1) Nematodes in soil
 - (2) Trichina
 - (3) Hook worm

III. Crayfish (as type of Crustacea)

1. Occurrence
 - a. Distribution
 - b. Habitat
2. Structure of body as a whole
 - a. Body divided into two parts: cephalothorax, abdomen.
 - b. Exoskeleton
 - c. Appendages
 - (1) Antennae
 - (2) Pinchers
 - (3) Walking legs
 - (4) Swimmerets
 - (5) Tail fin
 - d. Digestive system
 - e. Nervous system
 - f. Circulatory system
 - g. Excretory system
3. Reproduction and life history
 - a. Fertilized eggs
 - b. Eggs and young attached to swimmerets of female
 - c. Growth necessitates molting

4. Adaptations
 - a. Locomotion
 - (1) Walking by means of legs
 - (2) Swimming backwards by means of abdominal muscles and tail fin
 - b. Protection

(1) Color	(4) Speed in swimming
(2) Exoskeleton	(5) Stalked eyes
(3) Pinchers	
 - c. Feeding

(1) Claws and pinchers	(4) Senses
(2) Speed	(5) Color
(3) Mouth parts	
 - d. Respiration
 - (1) Gills protected by exoskeleton
 - (2) Gill bailer
5. Other crustacea

a. Lobster	c. Crawfish
b. Shrimp	d. Crab
6. Economic importance
 - a. Food for man and animals
 - b. Scavengers
 - c. Injury to river dikes

IV. Grasshopper (alternative for crayfish)

1. Occurrence
 - a. Distribution
 - b. Habitat
2. Structure of body as a whole
 - a. Three parts - head, thorax, abdomen
 - b. Exoskeleton
 - c. Appendages
 - (1) Legs
 - (2) Wings
 - (3) Antennae
 - d. Digestive system
 - e. Nervous system
 - f. Circulatory system
 - g. Respiratory system
 - h. Excretory system
3. Reproduction and life history
 - a. Fertilized egg masses deposited in the soil
 - b. Larva - nymph, incomplete metamorphosis
 - c. Growth necessitates molting
 - d. Development of wings
4. Adaptations
 - a. Locomotion
 - (1) Legs for walking or jumping
 - (2) Wings for flying
 - b. Protection
 - (1) Color resembles surroundings

- (2) Exoskeleton prevents injury
 - (3) Wings for rapid flying
 - (4) Strong hind legs for jumping
 - (5) Sense organs for detecting danger
 - (a) Antennae
 - (b) Eyes
 - (c) Tympanum membrane
 - c. Feeding
 - (1) Strong biting jaws
 - (2) Hooks on legs for support on stems of plants
 - d. Respiration
 - (1) Spiracles
 - (2) Trachea
 - e. Reproduction
 - (1) Ovipositor for depositing eggs (female)
5. Other insects. The insects are the most numerous of the animals of the world. Only insects representative of types are mentioned here for comparison with the grasshopper.
- | | |
|--------------|-------------------|
| a. Ant | f. Housefly |
| b. Aphid | g. Lady Beetle |
| c. Bee | h. Mosquito |
| d. Butterfly | i. Moth |
| e. Dragonfly | j. Praying mantis |
6. General characteristics of insects
- a. Exoskeleton
 - b. Three parts of body: head, thorax, abdomen
 - c. Jointed appendages
 - d. Spiracles and trachea for respiration
 - e. Many undergo complete, others, incomplete metamorphosis.
7. Increasing specialization and division of labor of the crayfish or grasshopper
- a. Exoskeleton
 - b. Jointed appendages
 - c. Sense organs
 - (1) Eyes
 - (2) Antennae
 - (3) Tympanum membrane
 - d. Respiratory system
 - (1) Gills in crustacea
 - (2) Spiracles and trachea in insects
 - e. Digestive system
 - (1) Mouth parts adapted for chewing or sucking
 - (2) Specialized organs
8. Compare briefly with other classes of Arthropoda
- a. Myriapoda
 - (1) Centipedes, millipeds
 - (2) Long bodies, many segments and many pairs of jointed appendages
 - b. Arachnida
 - (1) Spiders, scorpions, ticks

- (2) No antennae, four pairs of legs, head and thorax combined

9. Economic importance

a. Beneficial

- (1) Pollination of flowers
- (2) Production of fiber for cloth (silkworm)
- (3) Destruction of other harmful insects

b. Harmful

- (1) Destruction of plants valuable to man
- (2) Destruction of cloth, wood and other material valuable to man
- (3) Parasites on man and animals
- (4) Spread disease

c. Controls

- (1) Stomach poisons for biting insects
- (2) Contact poisons for sucking insects
- (3) Destruction of breeding places
- (4) Quarantine regulations
- (5) Birds eat many insects

V. Frog

1. Occurrence

- a. Distribution
- b. Habitat

2. Structure of body

a. Covering of moist skin

b. Appendages

- (1) Fore-legs for support
- (2) Posterior legs
 - (a) Strong for jumping and swimming
 - (b) Webbed feet for swimming

c. Internal skeleton

d. Head

- (1) Large mouth with sticky tongue attached in the front part
- (2) Protruding eyes with three lids
- (3) Nostrils connected with the mouth
- (4) Flat ear drum on the surface

e. Digestive system

- (1) Mouth
- (2) Esophagus
- (3) Stomach
- (4) Pancreas
- (5) Liver
- (6) Coiled intestine
- (7) Cloaca

f. Excretory system

- (1) Kidneys and cloacal bladder
- (2) Skin

g. Respiratory system

- (1) Lungs with short windpipe
- (2) Vocal cords (croaking)
- (3) Skin

- h. Nervous system
 - (1) Well developed brain
 - (2) Spinal cord
 - (3) Nerves
- 3. Life history
 - a. Reproduction
 - (1) Sexes separate
 - (2) Direct fertilization of eggs in water
 - (3) Development of fertilized eggs
 - (a) Singled fertilized egg
 - (b) Cleavage
 - (c) Morula stage
 - (d) Blastula stage
 - (e) Gastrula stage
 - (f) Tadpole
 - b. Tadpole, adapted to life in the water
 - (1) Tail for locomotion
 - (2) Gills for respiration
 - (3) Has no legs until later stages
 - c. Development of tadpole to frog
 - (1) Growth in size
 - (2) Legs develop
 - (3) Gills disappear
 - (4) Tail absorbed
 - (5) Adult frog
- 4. Adaptations of the frog
 - a. Protection
 - (1) Color - similar to surroundings
 - (2) Protruding eyes for better vision
 - (3) Posterior legs strong and feet webbed for jumping or swimming
 - (4) Slimy covering
 - (a) Aids in swimming
 - (b) Makes him difficult to hold when caught
 - (5) Ability to become dormant in winter when food is scarce and temperature is low
 - b. Feeding
 - (1) Large mouth for catching insects
 - (2) Sticky tongue attached in front for catching insects
 - c. Respiration
 - (1) Lungs while active
 - (2) Moist skin during dormant periods
- 5. Other related animals
 - a. Toad
 - b. Salamander
 - c. Newts
- 6. General characteristics of amphibia
 - a. Reproduce by eggs
 - b. Pass through a metamorphosis
 - c. Cold blooded
 - d. Three chambered heart, closed circulatory system

- e. Well developed brain
- 7. Increasing specialization and division of labor in the amphibians
 - a. Internal skeleton
 - b. Closed circulatory system with three chambered heart
 - c. More highly developed brain with spinal cord and nervous system
 - d. Digestive system more specialized with additional organs
 - (1) Liver
 - (2) Pancreas
- 8. Economic importance of amphibia
 - a. Food for man and animals
 - b. Destroy many insects

VI. Comparative study of other Chordata

1. Fish

- a. Examples

(1) Bass	(6) Mackerel
(2) Carp	(7) Perch
(3) Cod	(8) Pickerel
(4) Goldfish	(9) Salmon
(5) Herring	(10) Sucker
- b. Occurrence
 - (1) Distribution
 - (2) Habitat
- c. General characteristics
 - (1) Cold blooded
 - (2) Scaly covering (exoskeleton)
 - (3) Internal skeleton with backbone
 - (4) Fins for locomotion
 - (5) Gills for respiration
 - (6) Reproduction, oviparous
(Note exceptions)
 - (7) Care of young
 - (8) Two chambered heart
- d. Economic importance
 - (1) Food for man and animals
 - (2) Fertilizer for plants
 - (3) Scavengers
 - (4) Some destroy other valuable fish

2. Reptiles

- a. Examples

(1) Alligator	(6) Garter snake
(2) Black snake	(7) Lizard
(3) Cobra	(8) Rattle snake
(4) Copperhead	(9) Tortoise
(5) Crocodile	(10) Turtle
- b. Occurrence
 - (1) Distribution

(2) Habitat

c. General characteristics

- (1) Cold blooded
- (2) Scaly covering (exoskeleton)
- (3) Internal skeleton with backbone
- (4) Locomotion, some have legs, others do not
- (5) Lungs for respiration
- (6) Reproduction oviparous
(Note exceptions)
- (7) Care of young
- (8) Three chambered heart

d. Economic importance

- (1) Destroy insects and rodents
- (2) Supply leather and food for man
- (3) Food for other animals
- (4) Poisonous varieties injure man

3. Birds

a. Examples

- | | |
|---------------------|-------------|
| (1) Duck | (2) Eagle |
| (3) English sparrow | (7) Ostrich |
| (4) Goose | (8) Pigeon |
| (5) Hawk | (9) Robin |
| (6) Hen | (10) Turkey |

b. Occurrence

- (1) Distribution
- (2) Habitat

c. General characteristics

- (1) Warm blooded
- (2) Feathers for covering
- (3) Internal skeleton with backbone
- (4) Locomotion
 - (a) Wings
 - (b) Legs
- (5) Lungs for respiration
- (6) Reproduction, oviparous
- (7) Care of young
 - (a) Young are naked and helpless
 - (b) Young are covered with down and are active
- (8) Four chambered heart

d. Economic importance

- (1) Food for man and animals
- (2) Destroy insects and rodents
- (3) Supply beauty in nature in song and color
- (4) Pets
- (5) Destroy crops
- (6) Destroy valuable animals

4. Mammals

a. Examples

- | | |
|----------------|---------------|
| (1) Bat | (9) Man |
| (2) Camel | (10) Mole |
| (3) Chimpanzee | (11) Monkey |
| (4) Cow | (12) Rabbit |
| (5) Dog | (13) Rat |
| (6) Elephant | (14) Squirrel |

- (7) Horse
 - (8) Kangaroo
 - (15) Whale
 - (16) Woodchuck
- b. Occurrence
- (1) Distribution
 - (2) Habitat
- c. General characteristics
- (1) Warm blooded
 - (2) Hairy covering
 - (3) Locomotion - four limbs
 - (a) Walking
 - (b) Flying
 - (c) Swimming
 - (4) Internal skeleton with backbone
 - (5) Diaphragm between the thorax and abdomen
 - (6) Lungs for respiration
 - (7) Reproduction, viviparous
(Note exceptions)
 - (8) Care of young
 - (9)
 - (a) Mammary glands
 - (b) Pouched mammals
 - (c) Egg laying mammals
 - (10) Four chambered heart
- d. Economic importance
- (1) Beneficial. Mammals include the animals most important to man and most closely associated with man.
 - (a) Relation to civilization
 - (b) Food, meat, milk and milk products
 - (c) Clothing, wool, fur and leather
 - (d) Beast of burden
 - (e) Pets
 - (f) Game for hunting
 - (2) Harmful
 - (a) Destroy crops
 - (b) Destroy other animals more valuable
 - (c) Spread disease

UNIT IV

BIOLOGY OF MAN

UNIT IV

BIOLOGY OF MAN

Purpose of Unit: The purpose of this unit is to study the human body, its organs and functions, and to show how these aid man in adjusting himself to his environment.

I. General characteristics

1. The human body is upright
 - a. Legs and feet are adapted for walking
 - b. Arms and hands are free for grasping and holding
Thumb is opposite to the four fingers
2. Hairy covering is limited
3. Man is more intelligent than other animals

II. Sense organs

1. Eye - sensitive to light

Cornea	Retina	Aqueous humor
Iris	Sclerotic coat	Optic nerve
Pupil	Choroid coat	
Lens	Vitreous humor	
2. Ear - sensitive to sound

Outer ear	Tympanum	Eustachian tube
Inner ear	Semicircular canals	Auditory nerve
3. Nose - sensitive to odors

Nasal passages	Nerve endings	Olfactory nerve
----------------	---------------	-----------------
4. Tongue and palate - sensitive to taste
Papillae and taste buds
5. Skin - sensitive to touch

Cuticle	Sweat glands
Dermis	Sebaceous glands

III. Digestive system

1. Food
 - a. Carbohydrates
 - b. Hydrocarbons
 - c. Proteins
 - d. Minerals
 - e. Vitamins
2. Digestion of food
 - a. Mouth
 - (1) Teeth
 - (2) Tongue
 - (3) Salivary glands
 - (4) Ptyalin (enzyme) changes starch and sugar
to grape sugar

- b. Stomach
 - (1) Gastric glands secrete gastric juice
 - (a) Hydrochloric acid
 - (b) Pepsin
 - (c) Rennin
 - (2) Peristaltic movements
 - (3) Pylorus
- c. Intestine
 - (1) Receives bile from the liver
 - (2) Receives pancreatic juice from the pancreas
 - (3) Villi increase the area for absorption
- d. Final products of digestion
 - (1) Starch and sugar to grape sugar
 - (2) Proteins to amino acids
 - (3) Fats and oils to an emulsion

- 3. Absorption of foods
 - a. Largely in the small intestine
 - b. Glucose or grape sugar directly to the blood
May be stored in the liver as glycogen
 - c. Amino acids directly to the blood
 - d. Saponified fats to the lacteals and thoracic duct
thence to the blood

- 4. Uses of foods to the body
 - a. Proteins for tissue building
 - b. Fats for energy and heat, excess stored as fat
 - c. Sugar and starch for energy and heat
 - d. Minerals for blood, bones and teeth
 - e. Vitamins to promote health

IV. Nervous system

- 1. Divisions
 - a. Brain
 - (1) Cerebrum
 - (2) Cerebellum
 - (3) Medulla
 - (4) Gray matter
 - (5) White matter
 - b. Spinal cord
 - c. Nerves
 - (1) Sensory
 - (2) Motor
- 2. Nerve cells - neurons
 - a. Structure
 - b. Synapses
- 3. Nervous responses
 - a. Reflex
 - b. Voluntary act
 - c. Habit

V. Circulatory system

- 1. Organs

- a. Heart
- b. Arteries
- c. Capillaries
- d. Veins
- e. Lacteals; thoracic duct

2. Blood
 - a. Red blood corpuscles, containing haemoglobin
 - b. White corpuscles
 - c. Plasma
 - d. Fibrinogen
3. Functions
 - a. Distribution of food
 - b. Removal of waste
 - c. Regulate body temperature
 - d. Destroy disease germs
 - e. Heal wounds

VI. Excretory system

1. Organs
 - a. Kidneys - urea
 - b. Lungs - carbondioxide and water
 - c. Skin - water and urea?

VII. Endocrine gland system

1. Glands
 - a. Thyroid - thyroxine
 - b. Adrenal - adrenalin
 - c. Islands of Langerhan - Insulin
 - d. Pituitary - pituitrin
 - e. Thymus
 - f. Pineal
 - g. Parathyroid
 - h. Sex
2. General function
 - a. Regulate body activities
3. Relation to disease
 - a. Goiter
 - b. Addison's disease
 - c. Diabetes

VIII. Relation to environment. Because of his greater intelligence, man is able to exercise some control over:

1. Plants and animals
 - a. Destruction of wild plants and animals
 - b. Domestication of desired plants and animals
2. Disease
 - a. Knowledge of causes
 - b. Removal of causes
 - c. Use of vaccines
 - d. Use of quarrantine
 - e. Limited in control of epidemics

UNIT V

REPRODUCTION AND HEREDITY

UNIT V

REPRODUCTION AND HEREDITY

Purpose of Unit: The purpose of this unit is to study the methods of reproduction used by plants and animals and the laws of inheritance, and to develop an understanding of the elementary principles underlying plant and animal breeding and human heredity.

- I. Two methods of reproduction
 1. Asexual
 2. Sexual

Review reproduction of plants and animals indicating examples of asexual and sexual reproduction as studied in Units I and II.

Plants (Unit II)
 Algae and fungi
 Moss
 Ferns
 Flowering plants

Animals (Unit III)
 Amoeba and paramecium
 Hydras
 Earthworm
 Crayfish
 Frog

II. Additional examples of asexual reproduction

1. Natural methods
 - a. Runners or stolons
 - b. Bulbs
 - c. Roots
 - d. Leaves
2. Artificial methods (vegetative propagation)
 - a. Cuttings
 - b. Layering
 - c. Root division
 - d. Grafting and budding

III. Advantages of vegetative propagation over sexual reproduction

1. Plants propagate true
 - a. Fruits such as apples, peaches, pears are propagated by grafting or budding
 - b. Ornamental shrubs such as roses, Japanese maples by grafting or budding
2. The only method with plants which produce no seeds or very few seeds under the conditions of growth
 - a. Tulips, Narcissi are propagated by bulbs
 - b. Geraniums, sensiveria, coleus are propagated by cuttings
3. Provides a quicker method of propagating some plants than by sexual reproduction

- a. Chrysanthemums, Cacti develop more quickly from cuttings than from seeds

IV. Methods of sexual reproduction

1. Production of male cells (gametes)
 - a. Plants - in pollen grains produced by stamens
 - b. Animals - sperm cells produced by the testes
2. Production of female cells (gametes)
 - a. Plants - ovules in the ovary at the base of the pistil
 - b. Animals - ovules in the ovaries
3. Compare male and female gametes as to:
 - a. Motility
 - b. Size (stored food)
4. Methods of fertilization
 - a. Conjugation
 - (1) Spirogyra
 - (2) Paramecium
 - b. Fertilization in:
 - (1) Flowering plants
 - (2) Animals
 - (a) Hydra
 - (b) Earthworm
 - (c) Higher animals

External fertilization
Internal fertilization
 - c. Fertilized egg cell (zygote)
5. Development of fertilized egg cell
 - a. Cleavage
 - b. Morula
 - c. Blastula
 - d. Gastrula
 - e. Embryo
 - f. Adult

V. Inheritance in sexual reproduction

1. Character determiners in the nuclei of the cells
 - a. Chromosomes, composed of genes
 - b. Genes arranged in pairs
2. Division of chromosomes in cells for sexual reproduction (reduction division)
 - a. Egg cell contains one gene of each pair
 - b. Sperm cell contains one gene of each pair.
3. Fertilized egg cell (zygote) contains two genes for each character
 - a. One gene from the maternal parent
 - b. One gene from the paternal parent
 - c. Chance determines which genes are united in the fertilized egg cell

- VI. Mendel's Laws of Inheritance
1. Unit characters
 2. Dominance
 3. Segregation (monohybrid cross)
- VII. Variations among offspring
1. Characters acquired from environment
 2. Characters inherited from parents
 3. Mutations
 - a. Short-legged Ancon sheep
 - b. Hornless cattle
 - c. Seedless orange
- VIII. Applications of the laws of heredity to breeding:
1. Plants
 - a. Improvement in quality
 - (1) Fruits - apples, oranges, strawberries
 - (2) Potatoes - increase in size
 - (3) Corn - increase in fat and protein content
 - b. Increasing production
 - (1) Wheat
 - (2) Corn
 - (3) Potatoes
 - c. Ability to resist disease
 - (1) Rust-resistant snapdragons
 - (2) Wilt-resistant asters
 - (3) Rust-resistant wheat
 - d. Consult a flower catalogue for new varieties of plants offered
 2. Animals
 - a. Improved quality
 - (1) Beef cattle
 - (2) Dairy cattle
 - (3) Wool production in sheep
 - b. Increased production
 - (1) Beef cattle
 - (2) Dairy cattle
 - (3) Hens for egg production
 - c. Special purpose animals
 - (1) Draft horses
 - (2) Race horses
 - (3) Dogs for hunting, bull-fighting, etc.
- IX. Methods of plant and animal breeding
1. Selection of desirable individuals for propagation
 2. Hybridizing to secure new combinations of characters
 3. Selection of desirable hybrids for further propagation
 4. Inbreeding to get pure strain
 5. Watching for desirable mutations

- X. Human heredity
 - 1. Inheritance of mental ability
 - a. Jukes family
 - b. Kallikak family
 - c. Edwards family
 - d. Wedgewood-Galton-Darwin family
 - 2. Inheritance of other characters
 - a. Insanity
 - b. Haemophilia
 - c. Webbed fingers
 - d. Symphalangy
 - e. Other characters
- XI. Heredity versus environment
 - 1. Human character as affected by
 - a. Inherited characters
 - b. Education and training
 - c. Environmental conditions
 - 2. Information is gained by a study of identical twins
 - a. Similarity of genes
 - b. Differences in personality
- XII. Methods of improving the standards of human living conditions
 - 1. Related to heredity
 - a. General education of public concerning laws of heredity
 - b. Restriction of immigration to those physically and mentally fit
 - c. Restriction of reproduction by physically and mentally unfit
 - 2. Related to environment
 - a. Improvement of housing conditions
 - b. Enactment and enforcement of child labor laws
 - c. Compulsory education for all children
 - d. Maintenance of playgrounds in congested sections of large cities

UNIT VI

RELATION OF PLANTS AND ANIMALS TO THEIR ENVIRONMENT

UNIT VI

RELATION OF PLANTS AND ANIMALS TO THEIR ENVIRONMENT

Purpose of Unit: The purpose of this unit is to compare the methods by which plants and animals (1) adjust themselves to their environment, (2) provide for the success of the species and to study their relationship to men.

I. Plants and animals obtain food

1. Plants

a. Green

- (1) Manufacture their food by photosynthesis
 - (a) Green cells contain chlorophyll
 - (b) Materials used
 - Carbon-dioxide from the air
 - Water from the soil
 - (c) Energy from sunlight
 - (d) Food manufactured is sugar or starch
 - (e) Waste product is oxygen
- (2) Transport food materials through fibrovascular bundles
 - (a) Soil water up from the roots
 - (b) Sugar from the leaves to all living cells
- (3) Transform sugar and starch into other materials
 - (a) Woody cell walls
 - (b) Fats and oils
 - (c) Protoplasm by the addition of minerals

b. Non-green depend upon other plants for food

- (1) Saprophytes
 - Mushrooms, puffballs, yeast and others
- (2) Parasites
 - Smut fungi of oats, corn, wheat, etc. :
 - shelving fungi on living trees, fungus causing "athlete's foot" and others

c. Partial parasites

- (1) Dodder
- (2) Mistletoe

d. Insectivorous plants

- (1) Pitcher plant
- (2) Venus fly-trap
- (3) Sundew

e. (Optional) Are classified according to their water requirements

- (1) Xerophytes
 - (a) Resistant to drought or live in dry places
 - (b) Cactus, sage brush, mesquit
- (2) Mesophytes
 - (a) Live in regions of moderate water supply
 - (b) Common plants of field and forest

- (3) Hydrophytes
 - (a) Live in water or very wet soil
 - (b) Cat-tail, water lily, Swamp grass
(sedges)

2. Animals

- a. Obtain their food directly or indirectly from plants
 - (1) Herbivorous
Deer, woodchuck, partridge, prairie hen, grasshopper
 - (2) Carnivorous
Wolf, dog, lion, dragon fly, vulture, hawk
 - (3) Omnivorous
Rat, pig, hen, robin, man
 - (4) Insectivorous
Ant-eater, woodpecker, swallow, frog
- b. Digest food
 - (1) Starches and sugar changed to grape sugar
 - (2) Proteins changed to amino acids
 - (3) Fats and oils changed to an emulsion
- c. Use food to:
 - (1) Replace worn tissues
 - (2) Build new tissues (growth)
 - (3) Produce heat and energy

III. Plants and animals provide for the young

- 1. Plants by furnishing:
 - a. Food in the seed for growth of the plantlet
 - b. Adaptations favoring dispersal of seeds as:
 - (1) Hooks on seeds by which they are attached to animals - burdock, sticktight
 - (2) Appendages which aid in wind dispersal
Maple, elm, dandelion, milkweed
 - (3) Means for exploding seed pods
Touch-me-not, witch-hazel, beans
 - (4) Edible fruits to attract animals
Apple, cherry, walnut, hickory-nut
- 2. Animals by caring for their young
 - a. Lower animals produce many young; no parental care--House fly and other insects, frog, turtle, fish
 - b. Higher animals produce fewer young; give parental care
 - (1) Oviparous as birds protect and feed young
 - (2) Viviparous as mammals protect and suckle the young

IV. Plants and animals respond to stimuli

- 1. Plants and lower animals to simple stimuli
 - a. Stimuli - gravity, light, sunlight, water, contact, temperature
 - b. Responses - tropisms

2. Higher animals respond to complex stimuli
 - a. Stimuli - odor, taste, sound, contact, color
 - b. Reception of stimuli - sense organs
 - c. Responses
 - (1) Instinct
 - (2) Reflex
 - (3) Voluntary act
 - (4) Habit
- V. Over long periods of time plants and animals must adjust themselves to great changes in their environment
1. Method of accomplishing changes
 - a. More are reproduced than can survive
 - b. A struggle for existence results
 - c. Variations occur among individuals
 - d. Variations are inherited
 - e. The fittest survive
 2. Some species have been unsuccessful
 - a. Ancient species
Dinosaurs, flying reptiles, saber-toothed tiger, giant ferns
 - b. Modern species
Heath hen, passenger pigeon, great Irish deer
Bison, many others locally
 3. Some species have been successful
 - a. Animals as English sparrow, rats, mice, starling, house flies
 - b. Plants as daisy, dandelion, ragweed
- VI. Man has affected the number of species
1. Changed the environment
 - a. Removed forests, built cities, villages and farms
 - b. Irrigated deserts
 - c. Drained swamps
 - d. Polluted streams
 - e. Hunted game
 2. Increased some species
Domesticated plants and animals
 3. Destroyed other species
Beaver, bison, passenger pigeon, heath hen

UNIT VII

RISE OF MAN

UNIT VII

RISE OF MAN

Purpose of Unit: The purpose of this unit is to study the origin and evolution of man and his increasing control of environment.

I. Distribution

1. Probable origin - Asia
2. Early migrations
 - a. Europe
 - b. Africa
 - c. Asia
 - d. Australia
3. Modern migrations
 - a. Mass movements to:
 - (1) America
 - (2) Australia
 - b. Individuals through extended commerce and travel
4. Present day distribution in:
 - a. Temperate regions
 - b. Artic regions
 - c. Tropical regions
 - d. Continents

II. Evolution of man

1. Method of study
 - a. Remains of early man
 - (1) Buried in caves or ground
 - (2) Implements buried with the dead
 - (3) Kitchen middens
 - (4) Drawings on cave walls
 - (5) Bones and skeletons
 - (a) Java man
 - (b) Piltdown man
 - (c) Neanderthal man
 - (d) Cro-magnon man
 - (e) Others
 - b. Present day primitive man
 - (1) American Indians
 - (2) African Negro tribes
 - (3) Natives of Australia
 - (4) Eskimo
2. Stages of development
 - a. Old Stone Age (Paleolithic)
 - (1) Chipped stone implements
 - (2) Occupation - largely hunting and fishing
 - (3) Food
 - (a) Fruits, roots, stems of wild plants
 - (b) Flesh of animals

- (4) Clothing
 - (a) Skins of animals
- (5) Discovery of fire
- (6) Homes
 - (a) Tents made of skins and branches
 - (b) Caves
- b. New Stone Age (Neolithic)
 - (1) Polished ston implements
 - (2) Occupations
 - (a) Pastoral stage begins
Domestication of animals
 - (b) Agricultural stage begins
Domestication of plants
 - (3) Food - diet becomes more extensive
 - (4) Clothing
 - (a) Skins of animals
 - (b) Woven cloth from spun flax
 - (5) Erection of permanent homes
- c. Age of metals
 - (1) Copper age
 - (a) Discovery and smelting of copper
 - (b) Addition of copper utensils
 - (c) Migrations to secure copper
 - (d) Beginning of villages
 - (2) Bronze age
 - (a) Discovery of tin and gold
 - (b) Improved implements of bronze
 - (c) Increasing trade - seafaring
 - (d) Use of wooden plow in farming
 - (3) Iron age
 - (a) Bronze implements replaced by iron
 - (b) Modern food and clothing
 - (c) Increasing trade
 - (d) Beginning of modern machinery and manufacturing age

3. Races of man

- a. Caucasian
 - (1) Early distribution
 - (2) Present distribution
 - (3) Racial characteristics
 - (a) Skin color
 - (b) Hair color and texture
 - (c) Eye color
 - (d) Stature
 - (4) Subdivision of the Caucasian Race
 - (a) Nordic
 - (b) Alpine
 - (c) Mediterranean
 - (d) Hindu
- *b. Ethiopian
- *c. Mongolian
- *d. American Indian

*Use outline as for the study of the Caucasian Race

III. Man uses plants and animals

1. Plants

a. Food for man and animals

- | | | |
|--------------|-----------------|-----------------|
| (1) Wheat | (6) Barley | (11) Maple tree |
| (2) Rice | (7) Oats | (12) Grass |
| (3) Potatoes | (8) Beans | (13) Alfalfa |
| (4) Corn | (9) Sugar cane | |
| (5) Rye | (10) Sugar beet | |

b. Clothing

- (1) Cotton
- (2) Flax

c. Wood for lumber, paper, fuel, etc.

d. Rubber

e. Medicine

2. Animals

a. Food

- | | |
|------------|-------------|
| (1) Cattle | (4) Poultry |
| (2) Sheep | (5) Goats |
| (3) Hogs | (6) Others |

b. Beast of burden

- | | |
|--------------|--------------|
| (1) Horse | (5) Llama |
| (2) Ox | (6) Dog |
| (3) Camel | (7) Reindeer |
| (4) Elephant | |

c. Clothing

- (1) Sheep
- (2) Cattle
- (3) Silkworm
- (4) Reindeer
- (5) Others

d. Pets

Review economic importance of plants and animals to man as presented in Units I, II, and III.

IV. Man classifies plants and animals

1. Plants

a. Green plants

- (1) Algae
- (2) Mosses and liverworts
- (3) Ferns
- (4) Flowering plants

b. Non-green plants (Fungi)

- (1) Mushrooms
- (2) Others

2. Animals

a. Invertebrate

- (1) Protozoans
- (2) Worms
- (3) Mollusks
- (4) Insects

- b. Vertebrate
 - (1) Fish
 - (2) Amphibian
 - (3) Reptiles
 - (4) Birds
 - (5) Mammals

Alternative for Unit IV for more advanced study

IVa. Man classifies plants and animals

1. Purpose of classification

- a. To arrange in an orderly system for study and identification
- b. To assign to each a definite name (Latin binomial)
- c. To aid in understanding their characteristics and uses

2. Method of classification

a. Basis - differences in structures

b. Divisions

- | | |
|-------------|-------------|
| (1) Kingdom | (5) Family |
| (2) Phylum | (6) Genus |
| (3) Class | (7) Species |
| (4) Order | (8) Variety |

c. Latin Binomial name - genus and species names

3. Classification of Plants

4. Classification of animals

LITERATURE CITED

LITERATURE CITED

1. Anon. 17th Annual Report Education Department, The University of the State of New York (1920)
2. Anon. 22nd Annual Report Education Department, The University of the State of New York (1925)
3. Anon. 31st Annual Report Education Department, The University of the State of New York (1936)
4. Anon. Syllabus for Secondary Schools, Annual Report The New York State Education Department (1905)
5. Anon. Syllabus for Secondary Schools, Biologic Science The University of the State of New York (1911)
6. Anon. Syllabus for Secondary Schools, Biologic Science The University of the State of New York (1921)
7. Anon. Syllabus for Secondary Schools, Biologic Science The University of the State of New York (1931)
8. Anon. Syllabus in General Biology, New York State The University of the State of New York (1932)
9. Anon. Syllabus in General Science, New York State The University of the State of New York (1934)
10. Anon. Syllabus in General Biology, New York State The University of the State of New York (1936)
11. Anon. Syllabus in Elementary Science, New York State The University of the State of New York (1939)
12. Anon. Syllabus in General Biology, Board of Education, Rochester, New York (1939)
13. Anon. Regulations Relative to the Secondary School Curriculum and High School Diplomas, The University of the State of New York (1937)
14. Barber, Fred D. "The Reorganization of High School Science" School Science and Math 18:247-262 (April 1918)
15. Bayles, E. E. "Major Problems in the Teaching of Natural Science" School Science and Math 31:1048-1055 (December 1931)
16. Beck, Paul V. "The Organization of High School Biology on a Seasonal Basis" School Science and Math 35:717-721 (October 1935)
17. Brownell, Herbert and Wade, Frank B. "The teaching of

- Science and the Science Teacher" The Century Company
New York (1935)
18. Caldwell, Otis W. "Some Considerations Regarding Science and Mathematics" School Science and Math 37:840-843 (October 1937)
 19. Christy, Otto B. "The Development of Teaching of General Biology in the Secondary Schools" Journal of the Tennessee Academy of Science 11:278-287 (October, 1936)
 20. Christy, Otto B. "The Development of Teaching of General Biology in Secondary Schools" Journal of the Tennessee Academy of Science 12:273-308 (July 1937)
 21. Christy, Otto B. "The Development of Teaching of General Biology in Secondary Schools" Journal of the Tennessee Academy of Science 12:317-350 (October 1937)
 22. Coe, John Edwin "A Program for Socialization of Biology" School Science and Math. 37:775-781 (October 1937)
 23. Cunningham, Harry A. "Objectives in High School Biology" School Science and Math. 35:462-467 (May 1935)
 24. Cunningham, Harry A. "Objectives in High School Biology" School Science and Math. 35:606-612 (June 1935)
 25. Curtis, Francis D. "A Digest of Investigations in the Teaching of Science" P. Blakeston's Sons and Co. Philadelphia (1926)
 26. Curtis, Francis D. "Some Affects of the Depression on the Teaching of Science" School Science and Math. 35:360- (1935)
 27. Downing, Elliot R. "The Biology Course Outlined in Major Objectives" School Science and Math. 28:497-505 (1928)
 28. Edson et al. "Functions of Secondary Education" The University of the State of New York (1930)
 29. Hodgson, William C. "An Analysis of Courses and Methods Used in Teaching Biology in the Secondary Schools" Master's Thesis, University of Southern California
 30. Hunter, George W. "Is There a Sequence in Secondary Science?" School and Society 20:762-768
 31. Hunter, George W. "Science Teaching at Junior and Senior High Schools" American Book Company New York (1934)

32. Jones, Arthur P. "A Survey of the Educational and Social Adjustment of Forty C-level Students in Science Courses in the Albany High School" Master's Thesis New York State College for Teachers
33. Kelman, Lillian "A Proposed Course of Study for First Year Biology" Master's Thesis Brown University (1936)
34. Lloyd, Francis E. and Bigelow, Maurice A. "The Teaching of Biology in the Secondary School" Longmans, Green and Co. New York (1904)
35. Miller, David F. and Blades Glenn W. "Methods and Materials for Teaching Biological Sciences" McGraw-Hill Co., Inc. New York and London (1938)
36. Monahan, A. C. "Science and Its Recognition in the High School Curriculum" School Science and Math. 30:875-880 (November 1930)
37. Noll, Victor N. "The Teaching of Science in the Elementary and Secondary Schools" Longmans, Green and Co. New York (1939)
38. Sancliford, Peter "Educational Psychology" Longmans, Green and Co. New York and London (1928)
39. Stout, J. E. "The Development of the High School Curricula in the North Central States" Education Monograph No. 3 University of Chicago (1921)
40. Vesta, Holt "Status of Biology in the Secondary Schools of Oregon" School Science and Math. 27:121-128 (February 1927)
41. Warren, Mary J. "A Study of Various Factors Affecting Success in General Biology on the A, B, and C Levels in a Cosmopolitan City High School" Master's Thesis, New York State College for Teachers (1937)
42. Watkins, Ralph K. "The Future of the Special Sciences in the Senior High School" School Science and Math. 37:1089-1096 (December 1937)
43. Wells, Harrington "The Teaching of Nature Study and the Biological Sciences" Christopher Publishing House Boston (1936)

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