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Gentlemen of the Medical Class,—By the appointment of my colleagues of the Medical Faculty, and in conformity with a time-honored custom, it has become my pleasant duty to-day to welcome you to the commencement of your winter's studies. Some of you are now for the first time within these walls, for the purpose of devoting yourselves to the preparation for a noble profession, which is to be a life-long study and work. Others of you have come up here to extend and refresh the knowledge gained in previous years. Others, again, have been connected with the School during the summer term, which has been established by the Corporation of the University since the close of our last course of lectures. *You* are now to exchange the system of instruction by text-books and recitations, for that by lectures chiefly; with the aid of those appliances by which the student is enabled to learn directly from nature, and not at second-hand. To all the members of the class I extend, in the name of my colleagues, a cordial greeting.

Opportunity will be afforded to all who desire it for frequent examinations on the several subjects treated of in the lectures, and I wish to impress upon you the desirableness of taking part in these familiar, conversational examinations, as a means of fixing in your minds, and giving definiteness and precision to, the knowledge gained from lectures. Future success or failure may greatly depend upon the spirit with which you address yourselves to the labors upon which you are about to enter. A firm resolve and earnest endeavor will lighten much the toils of a rugged and difficult path; and you will gain not only the desired knowledge, but, what is much more, the mental discipline which enables its possessor to wisely use his information and experience. In the vast field of medicine and its collateral sciences, we are all learners. Our present medical science is the product of the observation and thought of many centuries. All true knowledge is a thing of slow growth. We succeed to the great inheritance of the accumulated wisdom of the past; and it is for us to rightly use this large legacy, and, so far as in us lies, to extend and carry forward the domain of true science into the regions of darkness and ignorance.

The subject to which I invite your present attention is a consideration of the relations of Chemistry to some of the departments of Medical Science; especially inquiring what kind and amount of assistance medicine can rightly expect from chemistry in its actual condition. I hope that the wholly inadequate manner in which I am able to present a subject of practical importance to the physician, may find some apology in long-continued ill health.

Chemistry has long been recognized as an essential branch of medical education, and invariably enters into the course of instruction in a medical school. Such was the case when the science was in a most infantile condition, and every step of advance has only made the connection more indispensable. It cannot be doubted that, in the future progress of medicine, it is to come into still closer relations and to exert a more vital influence. Already, physiology and pathology have reached a stage beyond which no important advance seems likely, unless with the aid of chemistry. Only so fast as *this* is carried onward, can *they* gain a firm basis for their growth.

Of all the physical sciences, probably none has seen so rapid and extraordinary a growth during the last half century, and more especially within the last ten or fifteen years, as chemistry. Looked at from some points of view, portions of the science have assumed almost the precision and certainty of mathematical demonstration. Its combinations and reactions are now to a large extent expressed by algebraic formulæ; and the chemist can predict the general chemical and physical properties of yet unknown and unformed compounds, much in the same manner as the old astronomers predicted eclipses, before the discovery of the causal law of universal gravitation. Nor is such prediction limited to compound bodies. One element, fluorine, has not been isolated, unless a colorless gas, lately obtained, should prove to be it. But no chemist is in doubt about the existence of fluorine, or in regard to the general properties which it will exhibit, if his art shall ever succeed in setting it at liberty.

Here, analogy is the guide. A well-known mineral, fluor spar, is ascertained to be a compound of calcium, the metallic base of lime, with the unknown substance. In its chemical properties and actions, it resembles the chloride, bromide and iodide of calcium. So, also, in its combinations with magnesium, barium and strontium; and in a lesser degree with various other bodies. Now all those which most nearly approximate fluor spar consist of an earthy metal in combination with one of three elements, forming a well-characterized, natural group. Analogy, then, suggests that as neither of these is present, an unknown body belonging to the same group must be. Its atomic weight and its place in the group are inferred from other data in a similar manner; and thus fluorine receives its name and its place in the series of chemical elements.

As was the case with astronomy, there is reason to expect that, in the future of chemistry, a still greater precision is to be reached; that a large part of the unwieldy mass of details and isolated facts will be compressed into a series of mathematical tables, as a result of the discovery of some central law of atomic combination. Though as yet ignorant even of the direction in which such a generalization can be sought for, we cannot doubt that some time the discovery of the great causal law lying at the basis of chemical combinations will reward the earnest seeker, and chemistry become, like its elder sister, astronomy, a truly exact science.

Such is its aspect from one point. Seen from another point of view, modern chemistry has expanded into a multiplicity of details impossible to be grasped and comprehended by the most patient student of facts. In the department of organic chemistry especially, besides a multitude of natural compounds, formed chiefly from four primitive elements—carbon, hydrogen, oxygen and nitrogen (constituting the group of organogens), there has been produced artificially a large series of quasi-elements, each attended by its multitudinous host of compounds. The most experienced chemists have never examined, nor even seen, one quarter part of the bodies thus obtained; and there appears no probable limit to the future extension of such series. Even now no one man can pretend to a thorough acquaintance with more than a small part of this wide field. Doubtless, this host of individual facts and isolated groups of facts will one day be marshalled under the banner of some wide generalization, and law and order be introduced into this scene of apparently inextricable confusion. Already, much progress has been made in grouping the organic compounds in series.

One of the more prominent changes which chemistry has experienced within a short period may be glanced at here, on account of its bearings upon the medical relations of the science. About sixty primary substances, called ultimate elements, variously united and compounded, are recognized as making up all the vast variety of material bodies, so far as these are known to the chemist. It being always understood that no one assumes that these, or any of these, are absolute elements; but only such as the known means of analysis have not succeeded in resolving into simpler constituents—that is, they are elementary, not in an absolute, but in a provisional sense of the term. Each of these bodies is known by its characteristic series of properties. Let us look now at some of the facts which are classed under the head of *allotropy*. The ultimate element phosphorus, for instance, is familiarly known as a nearly colorless, waxy-looking substance, readily fusible, and especially characterized by its marked inflammability, which requires it to be kept under water; and to which, indeed, it owes its name. If, now, a chemist of the old regime were presented with a quantity of brick-red powder, infusible, not luminous at ordinary temperatures, and totally uninflammable at any heat short of the very high one (about 500° Fahr.) which changes its allotropic state, he could scarcely be made to believe that the stranger was no other than his old acquaintance, phosphorus, in a new guise—with new chemical and physical properties. Yet such is the fact. It is not a new element; for, without adding or removing anything, phosphorus can by appropriate means be changed from one modification to the other at pleasure. Professor Schrötter, of Vienna, who first made the red phosphorus an object of special study, and discovered its allotropic condition, greatly astonished the chemists assembled at a scientific congress, by carrying a quantity of the red powder to the meeting in his waistcoat pocket. A hazardous experiment it might have proved, had not the substance been in a quiescent, inert state.

Carbon exists in at least three allotropic states, as charcoal, graphite and diamond; which have long been recognized as varieties, though not understood as exemplifying the phenomena of allotropy. With the properties of the leading element, oxygen, chemists felt themselves well acquainted a few years since. Now that the remarkable body *ozone* (so called from its powerful odor) has established its claim to an identity with the familiar, inodorous oxygen, it would seem as if the most firmly established principles of the science were likely to be uprooted. But it is not so. The former facts remain, venerable as of old, although added to and placed in new relations. Theories only must be modified and reconstructed.

Probably we are only at the threshold of great discoveries in the direction of allotropy. In what are these wonderful developments to end? Of the large series of metallic elements, many resemble each other more nearly than the several allotropic states of phosphorus or carbon do. May they not all be reducible to a few, perhaps to one or two? It will be seen that this leads us to the idea of the old alchemists, of the transmutability of the metals. The fond dream of those ancient enthusiasts may yet become a scientific reality, and the function of the anxiously sought philosopher's stone be fulfilled by some analytical process; which must, however, lie beyond the range of the most searching processes yet known, and of whose nature we can form no idea. Since the rise of modern chemistry, such speculations have until lately been indignantly scouted, and it has been held a fundamental axiom that the same body must always manifest the same chemical qualities, excepting only such variations as are due to the three conditions of solid, liquid and gas. Water we know as solid ice, as a liquid, and as gaseous steam. Many cases of allotropy are already clearly made out; and though no probable theory has been framed to include and explain these marvellous and unlooked-for phenomena, it is evident that the prevalent idea of chemical identity must be essentially modified.

The three elements, oxygen, carbon and phosphorus, enter as essential constituents into the animal organism. Perhaps the versatility of character which we have seen them to possess, may in some way fit them for the parts they are called upon to perform in the varied changes of animal life. Every extension of our knowledge opens unexpected vistas into the illimitable unknown; and probably the chemist of the present day feels more deeply than his predecessors that his science is but in its childhood—that in view of the possibilities which even now lie open before it, its past triumphs shall be far exceeded. Such innovations as allotropy promises to introduce, seem at first view likely to bring into doubt the best-established principles, and even to subvert the very foundations of the science. But soon they recede from their conspicuous position, gradually come to subtend a smaller angle in the field of view, and finally assume their true place in the structure which the labor and thought of many generations has been rearing. Even the errors and false theories of the past appear in a large view to be necessary steps in the history of progress. As the mountain traveller reaches a desired summit, only by repeated descents into valleys, and wide divergences, which seem to lead far away from the point at which he aims, so apparently inaccessible heights of science are scaled at last. Through uncertain wanderings and repeated failures, the student of science needs to feel that there are attainable truths within the reach of diligent search—that the divine Creator of the universe does not leave his children to wander in endless mazes of error and doubt—that no earnest and honest effort is made in vain.

Physiology and pathology are so directly dependent upon chemistry, that every step of its advance prepares the road for their progress—unfortunately, also, the erroneous theories and false generalizations, which inevitably crowd about the path of a rapidly extending science, become the bases of crude and hasty speculations, and of errors difficult to be eradicated. Formerly, physiologists maintained that chemistry had little or nothing to do with the phenomena of the living organism—that so long as life remained, chemical forces were held completely in abeyance. But now chemistry not only threatens to invade, but to overrun and annex the domain of physiology. The varied processes and products of the human organism, for example, are coming more and more under the recognized rule of purely chemical laws, and the present tendency of the cultivators of organic chemistry is to resolve the entire physiology of animal life into the two departments of Physiological Physics and Physiological Chemistry. Thus they supersede that mysterious vital force, which the elder physiology regards as the central, controlling power in the body; and convert the marvellous microcosm into a simple chemical laboratory. The great question thus opened, I can only presume to glance at here; merely expressing a conviction that physiology stands on a different plane from chemistry, as does chemistry from physics—that we might as well attempt to include all the varied reactions of chemical compounds within the laws of natural philosophy, as to believe that the organic germ, which is to develop into a complex animal organism, holds latent within it no other species of force than such as control the phenomena of the inorganic world. In every vital process, chemical and physical laws are in operation, but they are not the only ones involved. Over and above these are the mysterious laws of life. Chemistry can determine the ultimate elements out of which an organized structure is built up; and in a few instances has succeeded in forming a product of the organism artificially from inorganic materials. But organization is beyond its range. It has never been able, and it never will be able, to construct the simplest organic cell. It not only cannot build up organized bodies, but is unable to say how they are constructed, although familiarly acquainted with every one of the chemical elements which enter into their composition.

Chemistry cannot explain why prussic acid, a compound of carbon, hydrogen and nitrogen merely, should be a deadly poison. Even were it a corrosive substance, the quantity capable of destroying life immediately is so minute that it could exert no adequate chemical action on the organism. The relation of prussic acid to the living body is physiological, and not chemical.

Organized substances are, within certain limits, variable in composition. Thus the blood of man, or any species of animal, has not the fixed composition of a definite chemical compound; but varies in different individuals, and in the same individual at different times. It is even constantly fluctuating in composition. Organized substances cannot be confined within the precise and definite formulæ on which chemistry is based. Chemical analysis may lead us to the threshold of life, but beyond this it yields precedence to a new order of laws, which thenceforward assume the guidance.

Yet, the old idea of the vital principle as a force by whose aid living beings were supposed to withstand, not only chemical action, but every external agency, can no longer be maintained. So far from such resistance being in accordance with fact, the apparent permanence of the animal organism is but illusory. Ceaseless destruction and renewal are going on in every part of the body. Probably, each particle which takes part in producing a muscular movement, for instance, loses in the very act its vital connection with the organism, and is in consequence removed and replaced by another. Dr. Draper well illustrates this point by the following comparison. "What, then, is man? Is he not a form, as is the flame of a lamp, the temporary result and representative of myriads of atoms that are fast passing through states of change—a mechanism, the parts of which are unceasingly taken asunder, and as unceasingly replaced? The appearance of corporeal identity he presents year after year is only an illusion."—[Draper's Physiology, page 12.]

Most of the great natural forces are now known to be mutually convertible. If not identical in nature and origin, each is capable of developing any of the others, and in precisely equivalent proportions. Heat also stands in the same relation to electricity, magnetism and chemical affinity, and probably to light; for we must regard heat as a force, and not as a substance. Now this view has important physiological bearings. Thus, the received doctrine of respiration and animal heat assumes that the oxidation of a certain weight of carbon and hydrogen in the organism produces a certain amount of heat, as in ordinary combustion. In the body, it is not unlikely that heat and other forces, possibly also the nervous force, may exhibit this mutual convertibility; and respiration be something more than a purely chemical process.

Let us pass now to some of the relations of chemistry to the physiology of nutrition, as it occurs in the animal organism. According to the generally received theory, mainly developed by Liebig, the food of man and animals may be divided into two great classes—nitrogenized or tissue-making food, and non-nitrogenized or heat-making food. The first class includes the albumenoid bodies: chiefly albumen, fibrin and casein, which may be either of vegetable or animal origin. In chemical composition, these resemble the organized constituents of our tissues, and are alone capable of forming blood. Their most important element is nitrogen; their office that of building up the tissues and repairing the waste in them. The proportion of nitrogen which they contain represents their tissue-making power; and consequently their nutritive value can be ascertained by ultimate chemical analysis. On this basis, multitudes of analyses have been made of the various articles which enter into the food of man and the domestic animals, and tables constructed of their relative value as sources of nutriment.

The second class, that of non-nitrogenized foods, is subdivided into three groups. First—the fats, which are essentially compounds of carbon with hydrogen and a little oxygen. These undergo oxidation in the organism, producing carbonic acid and water, and maintaining the animal heat. Second—the carbo-hydrates, or compounds of carbon with oxygen and hydrogen, the two latter elements being in the same proportion as in water.

Starch and sugar are examples of these. Like the fats, they serve to support the heat of the body. The third group consists of inorganic substances, including water and various mineral bodies. These Liebig does not regard as essential constituents of the tissues into which they enter.

Such is the simple and beautiful theory of Liebig. Unfortunately, its simplicity results from leaving out of the calculation some of the essential elements of the problem. That it is inadequate and unsatisfactory, is beginning to be recognized by physiological chemists. While it can no longer be maintained as including all that is known on the subject, it has been of undoubted service in stimulating and guiding the researches, by whose results it is likely to be itself essentially modified, if not overthrown; for the present, it must hold its place as a convenient classification.

Let us see how Liebig explains the presence of non-nitrogenous substances, such as fat and water, in the tissues. "Fat," he allows, "is a never-failing constituent of the substance of the brain and nerves; hair, horn, claws, teeth and bones, always contain a certain amount of water and fat. But in these parts water and fat are only mechanically absorbed, as in a sponge, or enclosed in drops, as fat is in cells, and they may be removed by mechanical pressure, or by solvents, without in the least affecting the structure of the parts. They never have an organized form peculiar to themselves, but always take that of the parts, the pores of which they fill. They do not, therefore, belong to the plastic constituents of the body or of the food."—[Liebig's Chemical Letters.]

A physiologist who uses the microscope to examine the tissues, does not need a chemist to tell him that these statements are fallacious. Non-nitrogenous bodies and inorganic salts are as essential to the constitution of a tissue as its albumenoid base. On the other hand, it cannot be denied that albuminous substances are heat-producing, as well as tissue-making. Nor are inorganic substances less essential as constituents of the organism. The chemist who has occasion to analyze animal substances finds phosphate of lime in every solid and fluid of the body; and it cannot be removed from the constituents of the tissues without breaking up their chemical constitution. Chloride of sodium is almost if not quite universally present in the organism. Phosphorus is indispensable to the nerve-tissue, and iron to the blood corpuscles.*

Although no strict line of demarcation can be drawn between organic and inorganic chemistry, yet the products of vegetable and animal life present certain general characteristics which usually serve to distinguish them from substances of inorganic origin. None of the few chemical elements, out of which organic bodies, in all their infinite variety, are built up, are peculiar to them; nor do they change any of their special properties when they enter into

* For some of the above points I am indebted to a valuable series of articles on "Food and Drink," recently published in Blackwood's Magazine.

organic combinations. These few elements, combined in varying proportions, produce an endless series of compounds of diverse properties; often, indeed, give rise to two or more dissimilar bodies, when united in the same proportions. Organic compounds are generally of very unstable character, slight circumstances sufficing to break up the existing combination, and change it into others. These facts give to organic analysis quite a different character from inorganic.

Let us now consider what is meant by a chemical analysis, and what differences obtain in the modes of analysis applicable to inorganic and to organic bodies respectively. An appreciation of these points will help to a clearer understanding of the manner and extent to which the physician can avail himself of the aid of chemistry.

By the term ultimate analysis, the chemist understands the separation of a compound into the simplest known forms of matter; by proximate analysis, its resolution into bodies which, though more simple, are still compound. To take an instance from inorganic chemistry; sulphate of copper may be separated into its two proximate constituents, sulphuric acid and oxide of copper—and again, the sulphuric acid can be resolved into sulphur and oxygen, and the oxide of copper into copper and oxygen. Beyond this, it is not possible to go. We have now reached the ultimate elements.

The general character of the processes used is best shown by special examples. If we take a weighed portion of the red oxide of mercury (the red precipitate of the Pharmacopœia), and heat it in a small glass retort, it is separated into two substances, oxygen gas and metallic mercury, both of which can by appropriate means be collected and weighed. We obtain a heavy, opaque fluid, of brilliant metallic lustre; and a colorless, transparent gas, while the oxide has disappeared from the retort. Since the only metal, fluid at ordinary temperatures, is mercury, there can be no doubt as to its nature. The gas is known to be oxygen by actively supporting the combustion of a burning body introduced into it, and by other characters which I need not describe. The weight of the two products added together will equal the original weight of the oxide. Neither of them can be resolved by any process into simpler forms. They are, in the present state of our knowledge, ultimate elements. We have thus effected a complete analysis.

Proceeding now to a less simple case—suppose we wish to ascertain the presence and the amount of silver in lunar caustic, a compound of oxide of silver with nitric acid. We dissolve a known weight of the lunar caustic in water, and place in the solution a slip of metallic copper. In a short time, the whole of the silver will be deposited in the metallic state, upon the surface of the copper, from which it can be removed and weighed. Here we take advantage of the superior affinity of copper for oxygen and nitric acid, in consequence of which a part of the copper is dissolved to form a nitrate, and a corresponding amount of silver is set free. Or, we may separate the silver from solution, not in the metallic state, but in combination with chlorine; by adding to the solution one containing chlorine or a soluble compound of chlorine, such as common salt. The silver then separates as an insoluble chloride, which can be dried and weighed. Since chloride of silver invariably contains a certain proportion of that metal, the weight of silver present is calculated from that of the chloride obtained. Conversely, we can ascertain the proportion of chlorine in common salt, a compound of chlorine and sodium, by adding to its solution one of nitrate of silver. The weight of the chloride of silver obtained *now* indicates that of the chlorine present.

These examples will give an idea of the general nature of inorganic analysis. The definiteness of the compounds, and the small number capable of being formed from the same elements, give a high degree of precision and certainty to the processes. In dealing with an inorganic compound, all the ingredients present can usually be ascertained, and the relative weights of each; thus furnishing an invaluable means of checking and balancing the result, and ensuring its correctness.

Turning now to organic chemistry, we find a very different state of things. Here, such complete and exhaustive analyses as we have been considering are seldom practicable. The products of vegetable and animal life are divided into two great classes. The first class consists of *organized substances*, which show either to the naked eye, or under the microscope, a peculiar structure, other than that due to crystallization. Such are the cells and fibres which make up the various tissues of plants and animals. These, with few exceptions (such as starch granules and some varieties of cellulose), are not of homogeneous chemical composition.

The second class, called distinctively *organic bodies*, comprises all those products of vitality which do not possess organized structure. It includes the proximate constituents of the various secretions and excretions, which may be either solid, liquid or gaseous. In relation to analysis, this class may be conveniently divided into two groups—the crystallized and the amorphous organic bodies.

The first group includes such substances as the sugars, and many organic acids and alkaloids. Their susceptibility of crystallization renders it possible to isolate them from the foreign substances with which they may be mixed, and thus obtain them in a state of purity admitting of ultimate analysis. The second group includes many bodies of great physiological importance, such as albumen and fibrin. From the absence of crystalline form, many difficulties are experienced in obtaining them in a pure condition, and ascertaining when they are so. This circumstance renders the results of their analysis less certain.

Returning now to the bodies of the first class (organized substances), these cannot become properly the subjects of ultimate analysis, though it may be possible to separate in a few instances all the proximate elements which enter into their composition. An ultimate analysis of an organized body can of course be made, but is practically valueless. Most of the secretions and excretions of the animal organism consist of variable mixtures of several proximate principles. These also yield no valuable results to ultimate analysis. The several proximate principles must be disentangled and separated for individual analysis.

The undoubtedly valuable results, in a chemical point of view, yielded by organic analysis, and especially the great name of Liebig, have attached an exaggerated importance to the ultimate analysis of organic substances, in reference to physiology and pathology. The very term, organic analysis, is usually understood to mean only ultimate analysis. To Liebig mainly is due an immense advance in our knowledge of the ultimate components of organic substances, and in the modes of determining them. Still, the processes fall short of the precision attainable in inorganic chemistry.

An ultimate analysis requires a preliminary qualitative one, to ascertain what ingredients the compound contains, in addition to carbon, hydrogen and oxygen; and it is possible to overlook even important ones.

Ultimate analysis resolves itself mainly into a determination of the relative amount of each of the four organogens. The process consists essentially in burning the compound with a substance capable of affording oxygen. If we have a crystallized compound of carbon with hydrogen simply (as naphthalin), the result is satisfactory; the carbon being obtained in the form of carbonic acid, and the hydrogen in the form of water. If oxygen also is present, as in sugar and a vast proportion of organic bodies, a serious difficulty presents itself. There are no means known by which the oxygen can be determined directly; and it must be estimated by the loss, or difference between the original weight and that of the constituents which can be collected in a weighable form. It is obvious, that if an element has been overlooked in the preliminary qualitative analysis, the loss will be proportionally greater, unless it also yields a volatile product; and the whole loss will be rated as oxygen. This has occurred in the hands of the ablest chemists. Thus, the two proximate animal principles, cystin and taurin, contain more than twenty-five per cent. of sulphur, which was overlooked in the earlier analyses of these substances, and the amount of oxygen exaggerated in proportion. When nitrogen is present, it is determined by an additional analysis, and may be separated either in a pure state, or converted into ammonia, whose weight indicates that of the original nitrogen. Thus the chemist gains a knowledge of the elementary composition of a substance, of great value in a purely chemical point of view, but rarely available for the purposes of the collateral sciences.

Let us turn now to *proximate analysis*, and see what results this is capable of yielding. When the characteristic chemical properties of a proximate principle, such as diabetic sugar, have been once for all ascertained, we can determine its presence and amount in a complex fluid like the urine, without subjecting it to the combustion-tube, without even separating it from the fluid in a crystalline form. The presence of another foreign substance, albumen, in the urine, is readily ascertained by simple and satisfactory tests; and if requisite, it can be separated and weighed. Most of the normal constituents of the urine can be detected, and the variations in their amounts approximately determined, by simple tests. Now this is all the information which the physician can make use of for diagnosis at present. Since it is by the kidneys that a large part of the effete constituents of our organs, as well as their products, are eliminated from the system; it is evident that the variations of the urinary excretion furnish means of studying the diseases of the internal organs afforded in no other way. Pathological chemistry has not as yet succeeded in tracing to their origin many of the modifications brought to light by the use of tests; and an extensive field of research lies open in this direction.

A complete and exhaustive analysis of the urine has never been made, and, in the present state of science, cannot be made. All of its proximate constituents, even, are not known. The same observation applies in a still stronger degree to the blood. This fluid consists of a number of proximate principles, variously combined, and of organized bodies, as the red and white corpuscles, which are chemically of complex constitution. No means are known of isolating the several compounds present, so that each may be analyzed separately. Until this is accomplished, no thorough analysis is possible. A determination of the ultimate elements, and of their relative amounts, gives no information, since it is impossible to ascertain the states of combination in which they existed.

The day has passed by when chemists attempted to analyze a complex pathological product, such as cancer, by crushing the whole mass in a mortar, and endeavoring to extract from the heterogeneous medley a peculiar cancerous principle or schirrhin. The absurdity of such a procedure is now manifest; the progress of pathological anatomy, and the use of the microscope, have shown that such a tumor is built up of a variety of tissues and anatomical elements.

At the present day, analyses of the blood, both proximate and ultimate, are made, which though chemically correct, so far as they go, are necessarily imperfect and fallacious. Yet, these are quoted and reasoned from by physiologists, in the same manner as the mineralogist or geologist uses, in reference to mineralogy or geology, the chemical analysis of a mineral—altogether overlooking the radical and essential differences between a mineral analysis and that of a complicated organic compound.

Physiologists and pathologists often expect from chemical analysis information on points beyond its present range. Very many important theoretical and practical problems, which would seem to be within the reach of chemistry, could certain difficulties be overcome, must be content to lie in abeyance until processes of analysis shall be contrived, capable of dealing with them. I would not be understood to discourage the attacking of such problems: for it is likely that only by such attempts, and after repeated failures, can the present imperfect processes be improved. Only, let the experimenter be content to spend much time in improving the tools with which he works and learning their best use, before he adds to the mass of crude and worse than valueless analyses with which pathological chemistry especially abounds.

Every young experimenter is frequently meeting with apparently new and extraordinary facts, even in the most thoroughly explored fields of research; until experience teaches him what allowances to make for the errors of his modes of observation and the unavoidable imperfections which belong to all instruments and processes: not to speak of personal peculiarities of organization, such as the practical astronomer recognizes the effects of under the name of "personal equation." The chemist's appreciation of colors and odors, for instance, is influenced by personal peculiarities, and varies also in the same person at different times. The astronomer and the microscopist gradually learn to eliminate from their results the errors due to the imperfections of the telescope and the microscope. The experienced microscopist concentrates his attention on the special objects he is observing, and takes no notice of air-bubbles or other accidental bodies in the field of view—which may be the most conspicuous and noticeable objects to one who looks in the microscope for the first time. The errors of chemical tests and processes are less easily eliminated. So many difficulties environ any new research that there is little exaggeration in the remark of the German chemist, Mitscherlich, that the establishment of any chemical fact that was worth while, required fourteen years.

The impossibility of making a complete analysis of the blood or urine, by no means hinders the physician from gaining great assistance in the diagnosis of diseases by the application of chemical tests to these fluids—obtaining, in this way, positive and practically available replies, if the questions to which he seeks answers from nature are put in the proper form. Otherwise, an irrelevant answer is obtained, leading to error. Sometimes, the reply comes in a vague and indefinite shape, not easy to understand and interpret. Then, a change in the mode of applying the test, after the manner of a cross-examination, will often elicit information which nature seems chary of giving at first. A chief difficulty in dealing with a complicated mixture of proximate principles is to ascertain the influence of various accidental circumstances, and so to vary the reagents as to avoid these obstacles.

It is not enough for the student merely to see the processes of analysis and the application of tests as exhibited in the lecture room, and to listen to the explanations given. When he attempts to use them himself in actual practice, he is likely to find that processes which appear simple and easy, are not so to the beginner. He is sure to meet with unlooked-for fallacies, whose nature and causes can only be learned by personal experiment.

The examination of the urine requires but little general knowledge of chemistry and only moderate practice. Other investigations require more previous knowledge and experience. If the student can avail himself of a microscope, its aid will render the analysis of the urine, and of pathological products generally, more thorough and satisfactory, as well as far easier. The use of the microscope in conjunction with chemical tests is every day becoming more indispensable, not only for such analyses as the practising physician is able to make, but also in the elaborate researches required in the most accurate investigations, and in the department of inorganic as well as organic chemistry.

Without a general knowledge of chemistry, the physician can use chemical reagents for the purposes of diagnosis merely; as the navigator does not need a thorough comprehension of astronomy in order to determine the latitude and longitude of his ship, but is guided by rules, which are themselves the result of centuries of astronomical observation, and of intricate mathematical calculations. Still, it is better, when practicable, to know not only the rule, but the reason of the rule.

It cannot be doubted that, in the future history of medicine, its theory and practice are to gain a more exact scientific basis, by receiving from chemistry far greater aid than it is now competent to render. The opprobrium of uncertainty which hangs over medicine, will gradually lessen with every advance in our knowledge of the laws of nature relating to the human organism. May we never fail to remember that these laws, which true science reverently seeks to comprehend and apply, are not laws of man's contriving, but shadow forth the thoughts of the Divine Author of the universe.