Address.**THE MODERN CONCEPTIONS AND METHODS OF MEDICAL SCIENCE.***

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AN acquaintance with present conditions in medicine and with the literature of the past makes us aware of a great change, both in the conceptions of medicine and in the methods by which the conceptions are reached. There has been a great increase of knowledge brought about by investigation and experiment, a realization of the value of knowledge and its acceptance and utilization. Medicine has severed all connection with speculative philosophy and taken its true place among the natural sciences. It has been brought into closer accord with other sciences than ever before and has accepted the methods of science. There are no systems, no schools, no paramount authority; no hypothesis is so firmly held that it is not instantly rejected when it fails to accord with new knowledge. Progress in medicine has gone hand in hand with progress in all departments of knowledge.

Medicine has for its problems the cause, the nature, the prevention, the cure, of disease. It is a branch of biology in that in all of its relations it has to do with living things. The ontological conception of disease as a thing differing from and entering into the organism is no longer held, but disease is regarded as a condition of living things in which there is disharmony of function. The phenomena of life depend upon actions exerted upon living tissue by its surroundings. When the influences exerted lead to forms of activity which differ from and fail to come into accord with the usual activities, whatever produces such an influence is a cause of disease. The causative agencies acting on the tissue produce structural alterations, in consequence of which even the action exerted by the ordinary surroundings may result in disharmony. The terms health and disease both carry with them the conception of activity. Although the abnormality of function is always associated with and depends upon structural alteration there may be extensive structural alteration which is so repaired or compensated for that it does not result in disease.

In the history of the advance of knowledge in medicine we find two methods by which knowledge has been sought. In one the endeavor has been made to form conceptions of the objects studied by means of impressions conveyed by the senses. Great advances have always followed the discovery of methods and instruments by means of which the territory of investigation has been extended. The inquiry does not stop with the mere description of the conceptions derived from the sense impressions, but an effort is made to correlate them, to ascertain preceding conditions, and the meaning or idea involved. When the inquiry passes beyond the immediate investigation, an ideal conception of the nature, the

interrelation, the cause or the result of the condition studied, an hypothesis may be formed based on experience and analogy. The hypothesis must be tested by further observation under natural conditions and by the experiment which involves observation under known and controlled conditions. When the hypothesis has been so tested and found to hold good in all cases under the same conditions it can be used as a basis from which new questions may arise.

The other method is by speculation. By a wide and illegitimate use of analogy, conceptions are formed and projected into the objects instead of being derived from the sense impressions. A tendency to speculation is inherent in the nature of man. Confronted always with the unknown which has such enormous proportions compared with the known, and so much of which seems to be removed from the possibility of actual investigation, man is led to attempt to answer the questions which the unknown thrusts upon him by means of the imagination. As knowledge becomes deeper and more extended speculation tends to become more confined. True philosophy aims at a complete understanding of the causal relation of all processes in nature and of man's relation to these processes. Disease, as one of the most important conditions in nature affecting man in all of his relations has always had an important place in philosophy. All the systems of philosophy in the past from Plato down have embraced speculations concerning disease. The true ends of philosophy cannot be reached by speculation but by the use of all the material for observation given by the natural sciences, and a philosophical system will contain just so much truth as there is natural science in it. Nature seems to delight in refuting all conceptions of her processes which are not based on sense impressions.

The progress of knowledge by these two methods has been the same in all sciences as in medicine, but it is more easily followed in medicine because of the important place which its subject, disease, has always held in the thoughts of man. It is possible to trace the past in the conditions of the present. In the earliest period of medicine, before there were any records of the study of the phenomena of disease and any differentiation of disease, disease was regarded as the visitation of the wrath of offended deities, and the surest mode of its relief was the propitiation of the deity by supplications and offerings. Such beliefs are still held, or at least practices which were based on such beliefs are continued. In almost all countries at the present time it is the custom to offer supplications that the disease of an important individual may be removed by divine interposition. It is true that such prayers may be a part of past tradition or a part of the discipline of a religious system, but undoubtedly their efficacy is believed in by many. Disease has played an important role in systems of religion, and the teachers of the system who had most fully embraced its tenets were supposed to be the most efficacious in removing disease.

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Christian science is only one of a great number of religious systems held to-day in which treatment of disease forms an important part of the cult. In the past there have been systems of medicine which gave explanations of all phenomena, and the system being perfect the phenomena were removed from further investigation. Homeopathy is the most prominent survivor of such speculative systems.

Speculation has undoubtedly been fostered by systems of religion founded on what was accepted as supernatural revelation. Revelation which sufficed for the explanation of phenomena at the time when it was given becomes firmly and inseparably blended with speculation when it must be expanded to meet a wider range of phenomena. Knowledge cannot be diffused, accepted, or utilized beyond the general development of culture. Any general influence which can be exerted on the people, turning thought into new directions, giving new subjects and proper methods, is of great importance. Darwin by substituting a rational and easily comprehended hypothesis, based on observation and experiment, with a clear statement of the method by which the hypothesis was formed, for a revelation which did not suffice and which could not be twisted to conform to what was of general and accepted knowledge, exerted probably the greatest influence on general scientific progress in the last century. Medicine like all other sciences has felt its vivifying influence.

One of the greatest changes which has taken place in the last century is the general acceptance of the idea that medicine is a natural science in which knowledge must be sought by the methods of science, namely, observation and experiment, and that disease is the result of injurious conditions acting upon the tissues. A great part of the mystery surrounding disease has been removed by knowledge of the conditions which give rise to it with the further knowledge that it is possible to prevent disease by removing such conditions. Even though some may still believe that an epidemic of typhoid fever is an act of God, they must see that the action is exerted by means of a defective water supply, and that the surest way of removing the epidemic is not by supplication but by purifying the water. At no time in the world's history has the importance of knowledge been so fully recognized as at present. People see the application of knowledge in the arts, and that improvement in the processes involved is directly dependent upon increased knowledge of the processes. There is a closer union between science and art than has ever been before. We see the influence of the appreciation of knowledge in medicine in the general acceptance of the idea that the hospital in addition to taking care of the sick shall furnish facilities for the investigation of disease, in the creation of institutes devoted to the furtherance of medical knowledge and in endowments in universities to the same end.

A brief glance at some of the more important periods in medical history will enable us to trace the influence and the results of the two methods

by which knowledge has been sought. The history of medicine begins with Hippocrates. Before him there were only superstition and tradition without systematic observation and description. Hippocrates described accurately the results of his study of the phenomena of disease, classified the phenomena and based his methods of treatment on his observations. The influence of Greek philosophy made him attempt to explain the phenomena, by the assumption of a force residing in and presiding over the body. The contemporaries and successors of Hippocrates, who regarded him as a god and his conclusions as unailing axioms, entirely neglected the methods by which he arrived at them. It must ever remain a source of wonder that the light which burst upon medicine with the advent of Hippocrates should so soon have passed into darkness. The Greeks chose rather to speculate on the meaning of phenomena than to investigate them. Galen, next to Hippocrates, had the greatest influence on medicine, an influence which was dominant for more than fourteen hundred years. Galen mastered all the knowledge and traditions of medicine at his time and made important contributions to anatomy and physiology. He was the first to introduce the experimental method into medicine, and gave a firm foundation to nerve physiology by observing the paralysis of certain muscles after section of the nerves. A voluminous writer as well as investigator, Galen created a complete system of medicine which remained as authority until men became bold enough to throw over authority when it did not conform with what could be learned from investigation. The stagnation and decline in medicine which followed Galen and continued during the Middle Ages was due to the dominance of a dogmatic religion in lands in which the general culture of the people should have given the conditions for knowledge to increase. The Church regarded its dogma as sufficient, and all inquiry, all free activity of men's minds, was prohibited. Dogma based on supposed revelation sufficed. There was some attempt at progress made by the Arabians, but their most important contribution was the preservation of the old learning. Even the period of Renaissance passed with little or no influence on medicine, for activity was exclusively turned into channels in which dogma could not be disturbed.

Three circumstances served to bring about a new era in the progress of knowledge in which medicine shared. The discovery of the art of printing, by which knowledge became diffused and more exact by the substitution of record for tradition, the discovery of America with the stimulation which this gave to thought and imagination, and the Reformation which gave freedom to thought, removed the weight of authority and allowed investigation. The reform in medicine was introduced in Europe by Paracelsus whose work was chiefly the overthrow of the Galen system which had sufficed and under which investigation was not possible. Progress

in the new reform was more active in England than in the land of its birth. This was due to the freedom from war, the greater freedom of the people in all ways and to the work of Francis Bacon, who for the first time showed clearly the methods by which knowledge must be sought. With few exceptions English medicine has remained true to the precepts of Bacon, that knowledge increases by the observation of things with the proper utilization of past observations. There has been an almost continuous line of great physicians in England who have enriched medical knowledge by investigation and who remained free from speculation. The contributions which such men as Harvey, Sydenham, Hunter and Bright have made remain and have served as bases from which knowledge has grown. The theories which were founded upon their work have passed without influence. That there came a time in England when medical investigation was greatly surpassed in other countries is to be attributed to the introduction of methods of investigation which could not be utilized in England. It was the introduction of the laboratory with the facilities for, and the systematization of, medical investigation which gave medicine on the continent its ascendancy. Young men, at an age when authority has the least weight, and before there was opportunity given them for the investigation of the clinical phenomena of disease, found in the laboratory opportunity for investigation, and had small questions placed before them which could be solved. The laboratory gave the workers scientific methods which formed the basis and gave the direction of further work in the clinic. With the laboratory came also a division of labor which allowed certain men to devote their time to investigation and teaching. Ambition was stimulated for advance and the further career was made dependent upon the ability for investigation.

It is interesting to follow a wave of speculation in medicine which reached its acme in Germany in the early part of the nineteenth century. In the period following the Reformation the most striking figure in medicine was Albrecht v. Haller, a man who as investigator and clear thinker has been equalled by few. Haller recognized the important fact that life was a property inherent in the tissues and manifesting itself by sensation and movement. On the work of Haller is founded the system of Brown who though a Scotchman can be regarded as the forerunner of the German *Natur-Philosophie* in medicine. The system of Brown is founded on the principle which he states clearly that the living animal body is distinguished from the dead and from all lifeless matter by the capacity for excitation by external influences. The difference between health and disease lies in the degree of irritability of the tissues. He divided disease into the sthenic and asthenic types according to the degree of irritability developed by the excitant, and the treatment of disease was based on this. In the hands of Brown's pupils and successors treatment of disease was productive of

great harm. The theory of Brown found ready acceptance in Germany, not only by physicians but by a group of men who sought to explain nature by the creation of laws. The law once made was regarded as more correct than the observation. Schelling, who was the foremost figure in this philosophy, sought to give a representation of all the phenomena in nature, to develop the interrelation of the phenomena, to show the action of natural laws in all bodies, and that these laws originated in a common point and were characterized as an advancing series of higher phases of development of matter. Not only was it impossible to construct a system of the world from the knowledge of nature at that time, and it probably never will be possible, but Schelling very imperfectly utilized what knowledge there was. This *Natur-Philosophie* dominated medicine in Germany during the first quarter of the nineteenth century. It is expressed to a greater or less extent in all medical writing. The most gifted men could not entirely withdraw from its influence. Under it medicine was not a science following the methods of observation and experiment; investigation was banished from the clinic and laboratory and found its place at the writing desk. Hartmann says that one reason why the *Natur-Philosophie* found such ready acceptance was the ease with which it was possible by its aid to become famous as a writer. The young physician found it no longer necessary to become acquainted with the material for study by toilsome investigation; he only needed the philosophical forms of expression and could apply these to what he knew or did not know of medicine. Many systems of medicine were founded which purported to give a complete explanation of all the phenomena of disease. Of all these systems the one which has endured the longest was almost the most fantastic in its structure. The success of the system of Hahnemann or homeopathy is in the first place due to the fact that under it the treatment of disease represented a great advance as compared with treatment under the systems of Brown and Rasori. However zealous the exponents of a system may be it will find its condemnation from those who suffer most from it. The system as presented by Hahnemann was complete; it offered names and seeming explanations for all conditions. The practice of the medical art under the system was easy and involved no toilsome investigations. It was put forth at an early period of the *Natur-Philosophie* and was carried upward on the tidal wave which swept through Germany. It at once found great favor with the people and was taken up by great numbers of physicians. In the course of time the adherents of the system have become divided into three camps. In one its principles have been extended far beyond the conception of Hahnemann in that the products of disease have been used as remedial agents; a second have remained true to the principles of the founder, and a third, comprising a large number of intelligent physicians, hold only to the name. Under the *Natur-Philosophie* combinations between religion and

medicine arose, and a system which represented a return to medieval mysticism was formed by Windischmann and Ringseis. In this it was taught that the causes of disease are immaterial and not to be sought for, since disease merely represents discord between body and soul.

Such a remarkable phenomenon as the dominance of the speculation which was a part of the *Natur-Philosophie* must be regarded as a part of the romantic movement which swept through Germany and found its chief expression in poetry. All barriers to idealism and speculation were cast aside. The movement was a part of the awakening of Germany to a new national life. The great questions of the time involving political liberty and even national existence were absorbing. Under such circumstances only a few could turn from the pressure of such large questions to the narrow field of scientific investigation. It is remarkable that the great awakening in France which preceded it should have been characterized by the opposite tendencies. During this period of speculation in Germany valuable contributions to knowledge were continually being made in anatomy and physiology. The chief exponents of the *Natur-Philosophie* were physicians who had to do with the clinical phenomena of disease. Speculation was fostered because the methods of gaining information from the study of disease were at the time so meagre that observation was restricted. So confirmed was the habit of speculation that each new discovery in anatomy and physiology, instead of serving as a basis for investigation, became food for new speculation.

It is possible to see the influence of the *Natur-Philosophie* on its greatest opponent, Rudolf Virchow. No one more clearly laid down the methods of scientific investigation than did Virchow in the opening articles of his *Archives*. He was a born investigator and made valuable contributions to knowledge in every department of medicine. The protocols of his autopsies are models of full and accurate descriptions of observations. He made important additions to the technic and methods of work by the use of which new knowledge was gained. He was a great teacher as well as investigator, and men trained in his methods are among the most famous in medicine. It is difficult to find in the history of modern medicine any one who can be compared with Virchow in the contributions made to medical knowledge and in the influence which he exerted. He substituted for the ontological conception of disease, which was prevalent in Germany at that time, the conception which we adopt to-day, that it consists in life under altered conditions. This is not an explanation but a simple way of stating the summation of the most obvious phenomena. He created the cell theory of disease which, though it represented an enormous advance over prevalent theories and has been most stimulating to investigation, can no more be held in its entirety as Virchow gave it than any of the systems it supplanted. Unlike the other systems it did not pretend to be all-satisfying and all-explaining. The cell theory of disease should be regarded as an

hypothesis fully justified in being formed from the knowledge at that time available. In Virchow's theory of inflammation we see the great value of an hypothesis which though gradually proven incorrect by continued observations has been most stimulating to investigation. It is interesting to see the contention which has been excited by theory. No one contends for the acceptance of an observation but is content to leave this for time, but the contention is for the conception based on the observation and the theory formed from the conceptions. Virchow properly opposed the ontological conception of disease, but this led him also to oppose the proof given that certain diseases which he regarded as due to the action of general causes were due to parasites. Virchow appeared in medicine at the time when *Natur-Philosophie*, though seemingly dominant in Germany, was really far advanced in decline, and his mighty blows were delivered against a feeble body. It was the knowledge of French and English medicine, where the advance had been by investigation, the increase in knowledge in all the natural sciences giving too much to be covered by any system, which gave the death blow to this period of speculation in medicine.

It is possible now to see the effect of this period of unrestricted imagination on medicine. It is true that it inhibited progress by restricting observation and experiment, that it substituted theory for knowledge, and found satisfaction in empty phrases and juggling with terms. But it gave birth to fruitful stimulation and opened wide and distant vistas which science has utilized. The excitation of the imagination, provided the imagination be controlled and theories be recognized as theories, is most useful in science. Without the imagination, without the tendency to seek for explanations of phenomena, there would be no progress. There is only danger in the failure to recognize the true relation of the hypothesis and in attempting to progress by adding hypotheses. There was but little progress in the period, but progress resulted from the stimulation which the period gave and from the reaction which followed it. Although as playing a great part and affecting an entire people such a movement has passed and will probably not return, we constantly see the same tendencies. The medical systems often connected with religion which are constantly arising in all countries, and especially in this, the attempt to form theories in explanation of the unknown, are due to the same mental states which produced the *Natur-Philosophie*. They arise, have a ready following composed of birds of passage resting temporarily on any bough provided, and disappear without making any real impression. How completely the period of the *Natur-Philosophie* has passed in the country of the creation is seen in the history of medicine in Germany for the last fifty years. By the adoption of scientific methods, by the fostering influence of the government which provided facilities for research, and by a system which gave reward for investigation, Germany has become the leader of the world.

At no time in the world's history was there such rapid advance, such a complete transformation in methods, such an array of great men in all the departments of medicine as in France following the Revolution. The foremost of the men in this school in France was Bichat. He undertook the gigantic task of creating for medicine a solid foundation derived from the study of objects and from experiments. He carried the anatomical study of disease further than ever before, endeavoring to ascertain not only the lesions in the organs but in the tissues which compose them. The relation between the anatomical lesions and disorders of function, he says, must be studied by experiment. The work of Magendie in physiology was hardly less important than that of Bichat in pathology. Physiology had suffered from the theory of vital force which as a seeming explanation weighed upon it as an incubus, opposing investigation. He claimed for physiology the same methods as in physics and chemistry, saying that the carefully conducted experiment is alone decisive in testing the conclusions formed from observation of phenomena. The work of Magendie had full recognition in France and he was followed by Claude Bernard and Brown Séquard who further developed his methods. Corvisart, Andral, Louis, Rayer and Cruveilhier were among the most brilliant men in the new school which was founded by Bichat and Magendie. Corvisart and Laennec deserve especial mention, in that the former brought to general knowledge the method of percussion of Auenbrugger which had been forgotten, and the latter introduced and further developed the methods of auscultation.

In the advance of science new technical methods of investigation play a most important rôle. The technical method enables the observation to extend further and more deeply. Virchow has said that the introduction of the microscope into medical research enabled us to approach several hundred times nearer disease than before. The microscope introduced a new era in the study of disease; it came into general use when the study of gross pathology in the absence of new questions had almost reached its limit. It gave more correct ideas of disease by increasing the powers of observation, it overthrew at once many theories and gave new points of view and new questions from which further observation could proceed. Every improvement in the microscope by which its efficiency is increased has the same influence. The knowledge of the influence of bacteria in disease is due in the first instance to the improvement of the microscope, and in the second to the discovery by Koch of methods of cultivation by means of which the individual species can be studied. Until this was possible our knowledge of bacteria was inexact and their causative relation to disease only a hypothesis. The development of knowledge of the minute structure of cells and tissues is principally due to the use of methods of staining which started with the simple carmine stain of Gerlach. In clinical medicine the introduction of the microscope, the

thermometer, the methods of chemical investigation, the blood counter, the x-ray, have all led to a closer insight into disease and the substitution of knowledge for conjecture. There is a further indirect advantage which comes from the use of instruments of precision in investigating phenomena, in that the continued use of the methods, the constant seeking for exact knowledge of conditions, removes the tendency towards speculation.

The brilliant results which have been reached in surgery, changing this from the most despised to the leading branch of medicine, show the advantage of methods which are founded on knowledge. Surgery was despised in the period in medicine in which speculation was in the ascendancy, when the answers to its problems were sought in the study rather than at the bedside and in the laboratory. The art of surgery has been dependent upon direct observation of disease, and its remedial measures were applied to the disease as revealed by sense impressions. Theories and systems in medicine have come rather from internal medicine in which field the diseased conditions were not so susceptible to study as things. The broken leg, however, is revealed by sight and touch; the tumor is an object. Moreover, the training in the anatomical and other laboratories, so essential for a surgeon, gave the knowledge and the methods, and the manual skill to make them effective. At an early period surgery had recourse to animal experimentation, for the animal body offered the readiest means for testing new devices. In surgery new knowledge has been readily accepted and utilized. The first demonstration of anesthesia was made under the auspices of surgery, and the surgeon was the first to accept and apply the knowledge that infection is due to the action of living organisms. By the use of anesthesia and of measures of preventing infection, surgery has been extended into fields formerly supposed not to be open to the exercise of its art. Medicine owes a debt to surgery, for not only what it has accomplished but for holding to proper methods and demonstrating their importance. The less advance in modes of treating disease which internal medicine has made, compared with that made in surgery, is to be attributed to the difficulty of obtaining definite knowledge of the conditions of disease in internal organs.

That the lack of power is due primarily to lack of knowledge is shown by the fact that for diphtheria, formerly one of the most dreaded, now probably the best known, of diseases, there is a remedy which leaves little to be desired. The production of antitoxin is the greatest triumph of scientific medicine, and is due to knowledge obtained by the application of scientific methods to the study of a disease which gave unusual opportunities for investigation. It points out what may be accomplished in the future by not seeking for analogies between other diseases and diphtheria but by pursuing the same methods.

Modern therapeutics is guided by two principles in each of which efficiency is dependent upon

knowledge of disease. In the most important, the remedial agent has a specific action on the cause of disease, either destroying it or opposing its action. In the second, the remedial agents are used not with the view of exerting any specific action against the cause of disease nor even in assisting in the restoration of the tissue which has been injured but with the view of restoring function. Any agent acting as a cause of disease produces injury of the tissue, and the effect of this is alteration or diminution or destruction of function. There is a close interrelation of function, that of one organ depending upon the others. The effect of the alteration of function is seen in the supervention of phenomena which differ from the ordinary. The effect of impaired function may be remedied by supplying the body with some substance which was formed by the impaired organ. Substances directly derived from glands in the animal body, such as thyroid and pancreatic extract, may be supplied. Or the functional activity of an organ may be increased by direct stimulation or increasing its blood supply. Or the function of some other organ nearly related to the organ affected may, by increased function, be caused to supply the deficiency. Therapeutics acts either as a guard against or as a caretaker of the body in disease. Its greatest triumphs are in prevention. When the injury has once been produced its effects are minimized by the capacity of the body to adapt itself to new conditions. There is a third use in therapeutics in the case in which the disease produces so much pain and discomfort that the remedial agent is used for the purpose of diminishing the effect of sense impression on the central nervous system. It is clear how complicated the questions are and how much greater is the task presented to the physician than to the surgeon. The surgeon acts directly, either adjusting parts which are deranged or by removing tissue which is diseased. The study of medical literature shows the mistakes and follies which have been and are being perpetrated in therapeutics. The more obscure the disease the greater the number of remedies; the more ignorant the practitioner the more confidence that certain drugs will act as remedies in all diseases. Each year has served to discard some remedy considered infallible and to substitute for it another equally infallible. The discontent of the general public with such therapeutics is shown in the success of charlatans who advertise nostrums for the cure of all diseases. It is just as easy for them to obtain certificates of cures by the nostrums as it is for the practitioner to become convinced of cures effected by certain favorite drugs.

The greater knowledge of the infectious diseases which has come with their experimental study has especially served to place therapeutics upon a proper basis. It has become apparent that many diseases are self-limited and tend to recover under any treatment provided this be not too injurious, and that the medical art can be more successfully exerted in preventing disease

than in its cure. The first effect of increased knowledge of disease was to produce a feeling of powerlessness in the face of it, followed by a nihilism in therapeutics which was as much to be deplored as overconfidence for it acted as a bar to progress. This nihilism was a prominent feature of the Vienna school in the sixth decade of the past century. The science of therapeutics as we find it to-day is founded on experimental pharmacology and pathology. In experimental pharmacology the action of drugs on the healthy animal is investigated. It is sought to discover the mode of entry of the drug into the tissues, the mode of exertion, the changes the drug undergoes while in the body and the changes in structure and function it produces. The action of the drug may differ in different animal species. Knowledge of the pathology of disease shows in what part changes are produced by the causative agent, the nature of the changes, and the effect of these changes on function. The determination of what is taking place in the body in disease is the most important question in medicine to-day. For its answer all the resources of science must be brought to bear. The subject is rendered more complicated by the fact that we are not dealing with a fixed but with a variable quantity. Age, heredity, temperament and social environment must all be considered. We cannot say except with wide limitations what changes and variation in function will be produced by the action of certain conditions. With the knowledge of the effect of the drug on the healthy body, and the knowledge of what changes are being produced in disease, and the effect of which we wish to minimize, an intelligent experiment may be made. Previous experimentation on animals should deprive the experiment of all danger.

Another change which has become apparent is the greater specialization, not only in the exercise of the medical art but in investigation. All increase of knowledge must bring with it specialization, for with the enlargement of the field comes the impossibility of its control by one individual. Specialization has both advantages and disadvantages. The advantages are that investigations are more easily carried out by the simplification of the questions, and the familiarity with technical methods. Methods of investigation have become so complicated that the necessary skill can only be attained by the constant exercise of methods only applicable in a very narrow field, and an investigator of exceptional ability in one line of work may be powerless in another. A man may profitably devote his entire energies to the study of the changes in nerve cells in disease, or may confine himself to the study of a single species of bacteria. With the enormous increase in medical literature there has come specialization in this, and certain journals are devoted to special subjects and are read only by those working in the field covered. The first differentiation came in the separation of anatomy, physiology and pathology from practical medicine; that is, the medicine concerned with the exercise of the art. The separa-

tion was a natural one, for not only could progress be more rapid, but the subjects could be better taught by one who had the knowledge which came from his own investigations. It is no longer possible for a single individual to control the knowledge in any of these primary subdivisions. The most obvious disadvantage in specialization is the loss of the more general aspects of questions. The large questions become broken up into smaller, and the smaller questions become again leading questions to be again broken up. It is also felt that the knowledge gained in such special investigations may not be of a character which can be utilized in the treatment of disease. But few of the questions which arise and form the basis for investigation come from the clinic, and they apparently have only the most remote relation to the problems of disease. The investigator very properly feels that his investigations are justified in that they form contributions to general knowledge, and whether or not the results are directly applicable to the treatment of disease does not disturb him. There was an error perpetrated in not giving to those devoted to the study of the clinical aspect of disease the same opportunity to devote themselves to research, to answer the question which came from the phenomena of disease, which was given to anatomy, physiology and pathology. Clinical medicine, the study of the problems of disease coming from the bedside, must have the same opportunity, and must advance by the use of the same methods as physiology and anatomy. Clinical medicine is behind the special departments in the contributions it has made to knowledge, in the methods by which it seeks to advance, and in the efficiency of teaching. Provision must be made in the universities which will enable men in the clinical departments to devote themselves to research teaching, and laboratories must be provided for such research. Only one who is himself an investigator can direct investigation by recognizing and properly stating the questions. There need be no fear that the knowledge which comes from investigation will not be utilized. In what way may not be apparent at the time; often knowledge which seemed furthest removed from utility has become the most important. That knowledge is power, and that it is the only power is an accepted axiom.

Anatomy and physiology originally arising from human medicine for the furtherance of knowledge which could be applied to the treatment of disease in man have long outgrown such limitations. Both have become comparative. Physiology undertakes the study of the processes taking place in living things, anatomy their form and structure. The comparative view has more slowly entered into pathology, for this has been more closely in contact with clinical medicine, and most of the questions for investigation have arisen in connection with the diseases of man. Disease is found in every living thing, in all animal and plant life. The phenomena of disease must differ according to the conditions peculiar to the organism. Strictly speaking, there can be

little similarity between the phenomena of disease in a plant and in an animal. The functions which are destroyed or altered by disease are too dissimilar. But this is not true when we study the closer details of disease. In both, changes are produced, and the changes affect function. We can study unicellular organism directly under the microscope, see the changes which are being produced by injurious conditions and the effects of the changes. Knowledge derived from such study may be said to be the basis of our conception of inflammation. The studies of plant diseases have been almost entirely directed from the economic side. The economic results which have come from this study by enabling the prevention of disease are almost incalculable. General medicine has gained by this study a greater knowledge of parasites, their mode of action and the means by which the organism is protected against them. That the knowledge has been so rapidly gained is due to the facilities for investigation and experimentation. Plant experimentation has never given offense. It should be regarded on the whole as very much better that the study of plant disease has been directed from the economic side, for progress has been more rapid; but there would be advantage in the closer association of plant and animal pathology and the extension to plant diseases of questions coming from disease in man. Careful study of diseases in animals has been chiefly directed to the infectious diseases, and especially to those artificially produced. The questions have been chiefly those concerned with the parasitic cause of disease and the mode of action of the parasites. The more obscure diseases of animals have attracted but little attention, and only from the economic side. The phenomena of disease in the higher animals have much similarity to the phenomena of disease in man, and in certain aspects the diseases of animals are more capable of investigation. Diseases are found in animals which are similar to the most obscure diseases in man. Our ignorance of these diseases in man is due to their complexity and the difficulties of investigation. To their understanding chemical and physical methods are necessary, and some of these methods cannot be carried out for they may be harmful to the individual. In animals we have the advantage that the disease can be interrupted at any stage and the conditions studied at this stage. We know the infectious diseases of animals chiefly by their experimental production. There has been but little study of these diseases under natural conditions and much knowledge can be gained by the mode and conditions predisposing to infection. Questions of heredity have an important bearing on disease. The susceptibility of animals to disease varies. Common experience has shown in man, also, that under circumstances apparently the same certain individuals will acquire diseases, others remain exempt. There is also foundation for the belief that susceptibility for certain infectious diseases is inherited and in other diseases inherited sus-

ceptibility is beyond doubt. The most striking recent discovery in medicine is that the blood serum contains many complex substances. Some of them play an important rôle in the animal economy; for others we can as yet discern no purpose, and our knowledge of these substances is chiefly confined to their effects, but it has recently been found possible to isolate one substance in pure form with a known chemical composition. While these substances may serve an important rôle in protecting the body against disease they may act in the opposite way by providing a means by which injurious substances are brought in contact with cells. Whether chemical variation may not arise, be inherited and play an important part in disease susceptibility is an important question to be answered by comparative medicine. For the purpose of such investigation an animal clinic is necessary which should be provided with thorough facilities for the study of disease. The questions for solution should come both from comparative medicine and from the clinic of human disease.

Comparative medicine is intimately associated with experimental medicine. There can be no contention as to the relative advantages of observation and experiment. The experiment is only observation under simple and known conditions, and supplements observation under the more complicated natural conditions. In the experiment it is possible to divide questions into their simpler components and make each the subject of experiment. In experimental medicine, just as in the animal clinic, the questions for solution should come from both comparative medicine and the human clinic. The most brilliant results in experimental medicine have come from the study of the infectious diseases. Knowledge of these diseases stands in direct relation to the possibility of their experimental production. It is true that we have not been able to produce in animals many of the diseases which are found in man. Experimental medicine is comparatively new and the number of animal species experimented with has not been large. It has recently been found possible to produce syphilis in the chimpanzee, and there is every reason to hope that this will lead to knowledge of the nature of this most obscure disease. Questions concerning the circulation and respiration in disease which are closely related to physics will find their answer in experimental medicine. The opponents of animal experimentation should remember that the greater our knowledge of disease which comes in this way, the further will disease in man be removed from experiment. Before our present knowledge of diphtheria, tuberculosis, tetanus, and anthrax, all treatment of these diseases was experimental. In certain cases experiments must be carried out in human beings, and even when the experiments may have a fatal termination. Such experiments will only be resorted to when this forms the only method of obtaining knowledge of the highest importance, and the subjects of the experiment must be adults who submit with full knowledge of the possible con-

sequences. Let us give all honor to the men who devised and the brave men who submitted to an experiment, the knowledge obtained from which has placed yellow fever in the list of preventable diseases.

There has been in the past too wide a separation between the public and the medical profession. The public has derived its medical information chiefly through the newspapers, and the information so given has been sensational and unreliable. Without correct information of the problems which face the medical profession, and of the methods by which these problems are being solved, neither the sympathy nor co-operation of the public may be secured. Active or passive opposition may be encountered. There is evidence that this is being slowly changed. The medicine of the romance is not so fantastic as it was formerly. The general information in biology, human anatomy, and physiology necessary for any appreciation of medicine is being imparted by the schools. Many of the popular magazines contain admirable articles on disease. The stories of such diseases as malaria and yellow fever have actual fascination. The medical education of the public is also furthered by the work of boards of health in the control of infectious diseases. The public is slowly but none the less surely learning that disease is not a mysterious entity dwelling like a devil in the body, to be driven out by the use of some equally mysterious agent, but a condition of life which can be guarded against. The public is not slow in the appreciation of the results of the work of boards of health, and is willing to make provision for their work.

Medical education, the training of men to exercise the art of medicine, has been revolutionized in the past twenty-five years. The most marked change has been in the substitution of object study for the didactic lecture. The didactic lecture is still used, though not with the idea of imparting knowledge but of showing the interrelation of knowledge coming from object teaching. The successful practice of medicine depends more than ever before upon the use of methods which give accurate knowledge of the condition of the sick individual, and training in the exercise of these methods is the most important part of medical education. It is certainly of importance that the student should learn the structure of the body, the functions of the different organs, and the changes which organs and functions undergo in disease. The knowledge acquired will be constantly used in solving the problems presented in the practice of medicine. While this is true a great part of the value of these studies consists in the discipline which laboratory study enforces. In the laboratory the student learns to acquire conceptions of objects and of the activities taking place in them, by means of sense impressions, and to use and appreciate methods by means of which the field of investigation is extended. He learns to approach problems from the scientific point of view. Progress and success in medicine are directly dependent upon the habit of investiga-

tion. Medicine is not and probably will not be an exact science with definite laws by the application of which the exact sequence of phenomena can be foretold. Every case of disease is a problem, and on the knowledge acquired from investigation successful treatment of the individual depends. Science demands to know, and methods by which knowledge can be obtained are of supreme importance. Methods of obtaining knowledge have been widely extended in clinical investigation. Every year sees the discovery of new methods. There should be, and with the foremost men there is, no distinction between the clinic and the laboratory. In both knowledge is sought by the use of the senses, and methods of investigation have a supreme importance. The laboratory discipline can be given just as well in the clinic as in the other laboratories, with the advantage that the methods of the clinic are the methods which are used in the practice of medicine, and facility in methods can only be acquired by continual exercise. It is evident, however, that the laboratories and clinics should only be conducted by men who themselves know and fully appreciate the importance of methods. It is probable that in the medical education of the future there will be a restriction of the laboratory training in anatomy, physiology and pathology, and an extension of the training in the methods of the clinical laboratory.

Original Articles.

HEART COMPLICATIONS IN DIPHTHERIA. A CLINICAL STUDY OF 946 CASES.

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THIS paper consists of a clinical study of nearly one thousand cases of diphtheria treated at the Boston City Hospital, South Department, during one year. We have studied mainly the condition of the heart to determine the character and frequency of heart lesions and their practical importance in prognosis and treatment. We shall present some general statistics of all the cases, taking up certain cardiac signs and symptoms which were common to large numbers of the patients, and also a special consideration of a small group of cases in which the heart symptoms were especially prominent and important.

Age. — The patients, naturally, were mostly children; their ages were as follows:

Up to 1 year	57
From 1 to 5 years	331
From 5 to 10 years	248
From 10 to 16 years	109
Over 16 years	201

About 5% were less than one year, nearly 40% less than five years and about 70% less than ten years old.

Sex. — The sexes were almost equally represented.

Severity. — In about one quarter of the cases the course was mild, about one half were moderately ill and in one quarter the illness was severe. Over one half of the severe cases proved fatal, namely 132. This classification is based on the amount of toxemia, the amount of membrane and the presence of complications. The following table gives the number and per cent of deaths at different ages:

Whole no. of cases.	No. of deaths.	% of deaths.
1 year and under	57	19
1 to 5 years	331	43
5 to 10 years	248	20
10 to 16 years	109	6
Over 16 years	201	6

About one half of these patients died of bronchopneumonia, usually following operative interference, such as intubation or tracheotomy. About one fourth died of heart complications. Of the remaining one quarter, the majority died of early severe toxemia and a few of asphyxia, or late paralysis. These facts contradict Villy's statement that the majority of fatal cases of diphtheria die on account of heart complications.

About 50% of the patients were discharged from the hospital within four weeks, about 40% between the fourth and seventh weeks, only 10% remained longer than seven weeks. The length of the stay in the hospital was governed by the presence of diphtheria bacilli in the throat as well as by the severity of the illness.

BEGINNING OF TREATMENT.

The hospital patients come largely from the poorer classes where the illness is likely to be neglected at the outset and proper treatment deferred. In most of the cases treatment with antitoxin was not begun until the second or third day of the illness, and it is important to note that the large majority (at least two thirds) of the severe and fatal cases averaged four or five or more days without treatment with antitoxin.

CARDIAC SIGNS AND SYMPTOMS.

The physical signs of a greater or less degree of cardiac disturbance, such as murmurs, and rapid and irregular pulse, were very common. Ordinary symptoms of heart disease, such as dyspnea, dropsy, cyanosis and hemorrhage, were not common. We will take up the physical signs first on account of their far greater frequency.

PULSE RATE.

This table shows the relation between maximum pulse rates and mortality:

Pulse rate.	No. of cases.	No. of deaths.	% of deaths.
100 or under	127	4	3
100 to 120	114	11	9
120 to 140	378	19	5
140 to 160	226	33	14
Over 160	98	49	50