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*THE SCIENTIFIC ASPECT OF MODERN MEDICINE.**

THE origin and development of medical science are contemporaneous with the origin and development of mankind. So long as man has been, so long has been disease; and whenever man has suffered, man has tried to heal. The foundations of medicine lie deep in that soil of common knowledge from which arose all the sciences, and throughout its history it has freely absorbed the discoveries of them all. From the first it has been, and it must ever remain, their common meeting-place. In proportion as its spirit and its methods have been scientific it has progressed toward ultimate perfection. Yet, notwithstanding the importance of science to medicine, from first to last medicine has been permeated by the pernicious influence of empiricism. A wise man once said that all true science begins with empiricism, and medical science is a striking example of this fact. But it made an early effort to free itself. The most brilliant epoch of Grecian history is marked no more immortally by the wisdom of Socrates, the histories of Herodotus, the tragedies of Æschylus, and the art of Phidias, than by the medicine of Hippocrates and his followers, for this represents the first re-

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corded endeavor—and a mighty endeavor it was—to break away from the empiricism of the earlier ages. But the science of the time was meager, and, however laudable the aim, the Hippocratic writings are full of empirical notions. From that time on, down through the ages, we find science and empiricism, like the good and bad principles in all natures and all religions, ever contending. And the struggle still continues. As Richard Hooker wrote more than three hundred years ago, so to-day do 'Empirics learn physic by killing of the sick.' The empiricism of to-day is not solely the method of osteopaths, christian scientists, and vendors of patent nostrums; it is found in the schools and the practice of legitimate medicine. At times it has surprising successes; but the struggle is an unequal one, and science is sure to be victorious. At no period of the world's history has the scientific idea in medicine been so aggressive and advanced so rapidly as during the past fifty years, and at no time has it seemed nearer its ultimate victory than at this beginning of the twentieth century. This advance is so striking and so full of general interest that I have ventured to choose it as my subject to-day, under the title of 'The Scientific Aspect of Modern Medicine.'

The Idea of a Vital Force.—One of the most essential prerequisites of this advance was the complete and final liberation of medical science, and of all those sciences now comprehended under the general title of biology, from a burden which in one form or another had hampered progress from the earliest times. I mean the conception that living bodies possess within themselves an active force or principle, differing in nature from anything possessed by non-living bodies, and which represents the vitality of living things. The beginnings of this idea are found in the various forms of animism of savage races, according to which a spirit or ghost inhabits the body and is responsible for its actions. In diseased states, this good spirit is dispossessed by an evil one. In one form or another this belief is met with among all civilized peoples. It is found in the days of Salem witchcraft, and even as late as 1788, in Bristol, England, when seven devils were exorcised from an epileptic. In physiology, from the times of the early Greek medicine until after the Renaissance, the animistic idea is represented by the doctrine of the *pneuma,* or the 'spirits.' In Hippocratic times the spirits entered the body through the lungs, were carried by the blood to all parts, and enabled the vital actions to take place. At about 300 B.C., the Alexandrians found it convenient to make use of two forms of this mysterious agent, the 'vital spirits' residing in the heart, and the 'animal spirits' in the brain. To these, in the second century of the Christian era, Galen added a third, the 'natural spirits,' located in the liver.

All physicians of the present day are familiar with the remarkable story of Galen and his long reign in medicine. Born in the time of the emperor Hadrian, he lived an active life of medical research and practice. He was the imperial physician of Rome, and while the wise Marcus Aurelius was writing his 'Meditations,' Galen was producing his numerous medical books. These covered the whole field of the medicine of his time, much of which was the direct result of his own investigations. His activity was unparalleled, his knowledge immense, his logic and literary skill pronounced, and his system of medicine all-embracing. In these respects he was far above his contemporaries, and with the decline of the Roman civilization, the consequent disappearance of originality of thought, and the long unbroken sleep of research, what wonder is it that his brilliance should shine unrivaled through the dark ages?

For more than a thousand years following the death of Galen, his authority in all things medical was supreme, and the doctrine of the *pneuma* was unchallenged. Only when there came the intellectual awakening of the Renaissance did men ask themselves whether Galen's books or the human body more nearly represented the truth. But it was even long after this that the *pneuma* was deposed, and when it fell it was only to give place to the *archæus* of that archcharlatan, Paracelsus, and to the *anima sensitiva* of the mystic philosopher, Van Helmont, and the melancholy pietist, Stahl. Through the latter part of the eighteenth and the early part of the nineteenth century the vital principle was still in control of the physiologists, but, as they learned more of the conservation and the transformation of energy in inanimate things, and more of the working of living bodies, the gulf between the inanimate and the animate gradually narrowed, and the supremacy of the laws of chemistry and physics in all things living became clearly recognized. It is true that at times in these latter days, sporadic upshoots of a neo-vitalism raise their tiny heads, but these are to be ascribed to the innate aversion of the human mind to confess its ignorance of what it really does not know, and they do not receive serious attention from the more hopeful seekers after truth.

The elimination from scientific conceptions of the idea of vital force made possible a rational development of the science of physiology, and in this way led directly to the growth of a scientific medicine. In one of his luminous essays Huxley has written: "A scorner of physic once said that nature and disease may be compared to two men fighting, the doctor to a blind man with a club, who strikes into the melée, sometimes hitting the disease and sometimes hitting nature." * * * The interloper "had better not meddle at all, until his eyes are opened—until he can see the exact position of his antagonists, and make sure of the effect of his blows. But that which it behooves the physician to see, not, indeed, with his bodily eye, but with clear intellectual vision, is a process, and the chain of causation involved in that process. Disease * * * is a perturbation of the normal activities of a living body, and it is, and must remain, unintelligible, so long as we are ignorant of the nature of these normal activities. In other words, there could be no real science of pathology until the science of physiology had reached a degree of perfection unattained, and indeed unattainable, until quite recent times."

No period has been so rich in physiological discoveries as the last fifty years of the nineteenth century. Research has developed along two main lines, the physical and the chemical, and to-day physiology is rightly regarded as the foundation stone of the science of diseases, and thus as the basis of scientific treatment.

The Cell Doctrine.—At the time when vital force was having its death struggle, the cell doctrine was being born. Inseparably linked with the idea of the cell is the idea of protoplasm—protoplasm the living substance, the cell the morphological unit. The heretofore mysterious living body is a complex mass of minute living particles, and the life of the individual is the composite life of those particles.

Within the past few weeks the world has bowed in mourning over the bier of an aged man who, more than forty years age, in the strength of his vigorous manhood, gave to medical science in a well-rounded form the best of the cell doctrine of his time. Rudolf Virchow need have performed no other service than this to have secured worthy rank among the great men of medicine of the nineteenth century, for few books exercised a greater influence over medicine during that period than his 'Cellular Pathology.' From ancient times physicians had been divided into many camps regarding the cause of disease. One idea had been prominent for more than twenty centuries: The humoralists had maintained that pathological phenomena were due to the improper behavior or admixture of the liquids of the body, which were, in the original form of this theory, the four humors: blood, phlegm, yellow bile and black bile. According to the solidists, on the other hand, the offending agents were not the liquids but the solids, and especially the nervous tissues. Both humoralists and solidists were excessively speculative, and the growing scientific spirit of the nineteenth century was becoming impatient of hypotheses that could not be experimentally proved. The times were ripe for new ideas. Virchow, soon after taking the professor's chair at Berlin which he held from 1856 until his death, gave to an audience largely composed of medical practitioners, the lectures which, more than all else, have made him famous among his professional brethren. His main thesis was the cellular nature of all the structures and processes, whether normal or pathological, of all organized beings, and his dictum, '*omnis cellula e cellula*'—a cell arises only from an already existing cell is the keynote of his theories. With his microscope he demonstrated the cells in all the tissues of the body, whether normal or pathological, and he proved the origin of the morbid cells in the normal ones. As to processes, he maintained rightly that all parts of the body are irritable, that every vital action is the result of a stimulus acting upon an irritable part, and he claimed a complete analogy between physiological and pathological processes. Every morbid structure and every morbid process has its normal prototype.

Virchow's ideas aroused enthusiasm the world over, and were eagerly studied and largely accepted by progressive men of medicine. Time and research have corrected errors of detail, but no one now denies the cellular nature and physiological basis of pathological phenomena. These facts are fundamental to the understanding and treatment of disease, which is now universally regarded as the behavior of the body cells under the influence of an injurious environment.

Virchow's ideas regarding pathological formations are a fitting complement to the laws of the conservation and transformation of energy. In the living world, as in the non-living, the law of continuity holds good. There are no cataclysms, there is no new creation. Structure and energy, whether normal or abnormal, proceed from preexisting structure and energy. Only such a conception can make possible a scientific medicine, and, since its promulgation, medical advance has been rapid.

The Rise of Bacteriology.—During the past half-century, and largely during the past twenty-five years, that is, during the lifetime of this university, there has grown up a totally new science, comprising a vast literature and a vast subject matter, though dealing with the most minute of living things. This is the science of bacteriology. The achievements in this field have surpassed all others in their striking and revolutionary character, and bear both on the conception of the nature of a very large number of diseases, hitherto puzzling human understanding, and on their prevention and cure, hitherto baffling human skill. All other human deaths are few in number in comparison with those that have been caused by the infectious diseases.

Occurring the world over, constantly with us, invading all homes, and keeping the death rate in cities perpetually high, at times they have swept, with the fury of a fiery volcanic blast, over large regions of the earth's surface, sparing few, and leaving in their train empty households and cities of death. Recent statistics have claimed that one of these diseases, tuberculosis, alone kills one seventh of all the population of the world.

To what are these pestilential visitations due? Many have said, 'To the anger of offended gods'; others, 'To the displeasure of a divine Providence'; the early physicians, 'To a wrong admixture of the humors'; the later pathologists, 'To mysterious fermentations.' But none of these answers has touched the vital point. This was reserved for a simple, modest and earnest student of science, of humble origin, the son of a French tanner, a man unhampered by medical tradition, seeking only the truth, and possessed of no genius except the genius of perseverance. To Louis Pasteur, more than to all others, should be given the honor of having solved the problem of the causation of these dread diseases. He laid the foundations of the new science, broad and deep, with surprisingly few errors of judgment.

It is instructive to look at the leading features of Pasteur's life-work. From the beginning of his career, Pasteur was the defender of pure science, yet his work demonstrates well the ultimate practical value of what seems at first purely scientific. At the age of thirty-one he became a professor and dean of the Faculty of Sciences at Lille, and in his opening address he said to his students: 'You are not to share the opinions of those narrow minds who disdain everything in science that has not an immediate application.' And then he quoted that charming story of Benjamin Franklin, who when witnessing a demonstration of a scientific discovery, was asked: 'But what is the *use* of it?' Franklin replied: 'What is the use of a new-born child?'

Pasteur's various scientific labors form a strikingly connected series, each being logically bound to those that preceded it. Beginning with a study of the forms and significance of the crystals of certain salts, in which he made use of fermentation processes, he passed directly to the study of fermentation itself. He early appreciated the fact that this phenomenon, due as it is to the presence in fermentable liquids of microscopic living bodies, bears significantly on fundamental physiological processes; and his labors directly established the germ theory of fermentation. Fermentation led to his famous investigation of the problem of spontaneous generation, which for ages had vexed the scientific and popular mind. Organic liquids exposed to air soon become putrid and filled with microscopic beings, the origin of which was a mystery. Many believed them to originate spontaneously; others thought that the air contained a mysterious creative influence. 'If in the air,' thought Pasteur, 'let us find it'; and by the simple device of stopping the mouths of flasks of sterilized liquids by a bit of cotton-wool, he was able to filter out the influence and keep his liquids pure and free from life. At the end of a year's active work he announced a most important fact: 'Gases, fluids, electricity, magnetism, ozone, things known or things occult, there is nothing in the air that is conditional to life except the germs that it carries.' His position was assailed by clever men, and he was forced to defend himself. It was here that his power of perseverance first formidably asserted itself. The struggle lasted for years, and Pasteur repelled each attack, point by point, with facts acquired by ingenious experimentation, with the ultimate result of giving to the doctrine of spontaneous generation its death blow.

Fermentation and spontaneous generation prepared Pasteur for his next victory. The French wine trade was threatened with disaster. Wines prepared by the accepted methods often became sour, bitter or ropy. It was said that they suffered from diseases, and the situation was critical. It was Pasteur's achievement not only to prove that the diseases were fermentations, caused not spontaneously but by microscopic germs, but also to suggest the simple but effective remedy of heating the bottles and thus destroying the offending organisms.

It seemed a long step from the diseases of wines to the diseases of silkworms, yet when a serious epidemic, killing the worms by thousands, threatened irreparable injury to the silk industry, it was only natural that Pasteur, with his growing reputation for solving mysteries by the diligent application of scientific method, should be called upon to aid. He responded with his customary enthusiasm, and for five years diligently sought the cause of the trouble and the cure. Though stricken by paralysis in the midst of his work, in consequence of which for a time his life hung in the balance, in three months he was again in his laboratory. Here, as in his previous labors, he achieved final success. He proved that the silkworms were infested with distinct diseases, due to easily recognizable germs. Furthermore, he devised efficient methods of eliminating the diseases, and thus he relieved from its precarious condition the silk industry of France and of the world.

By the year 1870 Pasteur's success had already assured him, at less than fifty years of age, a commanding place in the scientific world. His demonstrations of the all-important parts played by microscopic organisms in the phenomena which he had studied, had stimulated widespread investigation. He had already dreamed of the germinal nature of human diseases; and now medicine, which had long suspected them to be associated with fermentation processes, began to appreciate the significance of the new discoveries. In 1873 he was elected to fill a vacancy in the French Academy of Medicine, and from that time on he gave more exclusive attention to pathological phenomena. He investigated septicemia, puerperal fever, chicken cholera, splenic fever, swine fever, and lastly rabies. To speak at length of what he accomplished in this field would require much time. I would, however, mention one salient incident.

One day chance revealed to him a unique phenomenon, the further study of which led to one of his most significant discoveries. In the inoculation of some fowls with chicken cholera, not having a fresh culture of the germs, he used one that had been prepared a few weeks before. To his surprise, the fowls, instead of succumbing to the resultant disease, recovered, and later proved resistant to fresh and virulent germs. This was the origin of the pregnant idea of the *attenuation,* or weakening, of virus, which, nearly a hundred years before, Jenner unknowingly had demonstrated in his vaccinations against smallpox, and which had been employed by physicians in all the intervening time. By various methods of attenuation Pasteur succeeded in producing vaccines from the virus of several diseases, and he perfected the process of vaccinating animals and thus protecting them from attacks of the disease in question.

The story of Pasteur's brilliant investigations of hydrophobia is too recent and too well known to relate here. They form a fitting ending to a life rich in scientific achievement, stimulating to research, and momentous in the history of scientific medicine.

In the summer of 1886 it was my good fortune to spend a few hours in the presence of this man in the rooms of the then newly organized Pasteur Institute in Paris. It was in the early days of the practical application of the results of his long-continued, devoted experimentation regarding the cause and treatment of hydrophobia. In a large room there was gathered together a motley company of perhaps two hundred persons, most of whom had been bitten by rabid animals. Men, women and children, from the aged to babes in the arms of their mothers, richly dressed and poorly dressed, gentle folk and rude folk, the burgher and the peasant; from the boulevards and the slums of Paris, from the north, south, east and west of France, from across the Channel in England, from the forests and steppes of Russia where rabid wolves menace, from more distant lands and even from across the seas—all had rushed impetuously from the scene of their wounding to this one laboratory to obtain relief before it was too late. All was done systematically and in order. The patients had previously been examined and classified, and each class passed for treatment into a small room at the side: first, the newcomers, whose treatment was just beginning; then, in regular order, those who were in successive stages of the cure; and, lastly, the healed, who were about to be happily discharged. The inoculations were performed by assistants. But Pasteur himself was carefully overseeing all things, now assuring himself that the solutions and the procedure were correct, now advising this patient, now encouraging that one, ever watchful and alert and sympathetic, with that earnest face of his keenly alive to the anxieties and sufferings of his patients, and especially pained by the tears of the little children, which he tried to check by filling their hands from a generous jar of bonbons. It was an inspiring and instructive scene, and I do not doubt that to Pasteur, with his impressionable nature, it was an abundant reward for years of hard labor, spent partly in his laboratory with test-tubes and microscopes, and partly in the halls of learned societies, combating the doubts of unbelievers and scoffers, and compelling the medical world to give up its unscientific traditions and accept what he knew to be the truth.

Modern Surgery.—The earliest practical application to human disease of the results of Pasteur's labors was made in the field of surgery. The horrors of the early surgery had been largely eliminated by the discovery of the anesthetic effects of chloroform and ether, and the possibility of their safe employment with human beings. But the successful outcome of an operation was still uncertain. No one could foretell when the dreaded septic blood-poisoning might supervene and carry off the patient in spite of the most watchful care. Many hospitals were only death traps, the surgical patient who was taken to them being doomed to almost certain death. The suffering of the wounded in our Civil War was extreme, and during the Franco-Prussian War, the French military hospitals were festering sources of corruption, their wounded dying by thousands. To Pasteur, who realized only too well that the cause of death lay in the germs that were allowed to enter the wounds from the outside, this unnecessary suffering and death of so many brave French youths was a source of intense grief. Yet, notwithstanding his protestations and the urging of his views upon those who were immediately responsible, little good was then accomplished, for the

French surgeons were slow to adopt new ideas.

In England Lister was more successful. Fired by Pasteur's discoveries regarding fermentation and putrefaction, he conceived the idea of using carbolic acid in the vicinity of the wound while an operation was being performed, for the purpose of destroying whatever germs might be floating in the air or adherent to the surfaces. This was employed successfully, and at once the mortality of surgical operations was greatly diminished. This was the beginning of the aseptic surgery of the present day, and, in the light of what it has accomplished, Lister's achievement shines with brilliance. Carbolic acid was soon discontinued, owing to more efficient aseptic agents and methods of absolute cleanliness, but the essence of the modern surgical method is the same as at first, namely, to prevent the living germs from entering the wound. Septicemia and pyemia are no longer to be dreaded, the successful outcome of surgical procedure is practically assured, and operations that were undreamed of twenty-five years ago are now daily occurrences in the hospitals of the world. The most remarkable are those that come under the general head of laparotomy, which requires the opening of the abdominal cavity, and those performed on the brain. It may be said that the greatest development of scientific or aseptic surgery has occurred in America. Here the typical American traits of ingenuity, independence and courage have borne good fruit.

Disease Germs.—Pasteur's work was epoch-making. Apart from its revolutionizing the methods of practical surgery, it has completely changed our conception of the nature and the mode of treatment of the whole group of germ or zymotic diseases, and has gone far toward solving a host of long-existing and puzzling problems of general pathology. The actual discovery of the germs of human diseases and the proofs of their specific morbific properties did not fall within Pasteur's province. Such achievement has been the lot of others, most brilliant among whom is undoubtedly Robert Koch. The bacillus of anthrax, or splenic fever, was seen in 1838 by a French veterinarian named Delafond, but its part as the causative agent of the disease was first shown by Koch in 1876, this being the first conclusive demonstration of the production of a specific human disease by a specific bacterium. Think how recent was this event, so significant for the development of a scientific medicine and for the welfare of the human race! Koch's demonstration was made but twenty-six years ago, eleven years after the close of our Civil War. But it was only after repeated subsequent experiments and the piling of proof on proof by Koch, Pasteur and others, that the new idea was generally accepted. Since then discovery has followed discovery, and the world watches eagerly for each new announcement. Koch acquired new laurels in 1882 by demonstrating the germ of tuberculosis, and in 1884 that of the terrifying Asiatic cholera. In 1884, also, Klebs and Löffler found the bacillus of diphtheria, and several investigators that of tetanus. The year 1892 revealed the bacillus of influenza, and 1894 that of bubonic plague. Besides these instances, the part played by specific germs in many other diseases has already become recognized. Smallpox, measles, hydrophobia and yellow fever still defy the investigators, but no one doubts their germinal nature.

But scientific medicine is not content with describing species of bacteria and proving their connection with specific diseases. It must show what these organisms do within the body, how they cause disease, and by what procedure their evil activities may be nullified. Persistent and devoted research has already thrown much light on these problems, yet so much is still obscure that it is difficult to generalize from our present knowledge. The germs find lodgment in appropriate places, and proceed to grow and multiply, feeding upon the nutrient substance of their host. In certain diseases, if not in all, their activities result in the production of specific poisonous substances called *toxins,* which, being eliminated from the bacterial cells, pass into the cells of the host and there exert their poisonous effects. These effects vary in detail with the species of bacterium; and thus the individual, suffering from the behavior of his unwonted guests, exhibits the specific symptoms of the disease.

Preventive Medicine.—In looking over the history of the search for a means of cure, one is struck by the great value of the ounce of prevention. Keeping the germs out is in every way preferable to dealing with them after they have once entered the body. This fact scientific medicine is impressing more and more deeply on the minds of public authorities and the people, and their response in the form of provisions for improved public and private sanitation is one of the striking features of the social progress of the present time. All the more enlightened nations, states and cities of the world possess organized departments of health, which, with varying degrees of thoroughness, deal with the problems presented by the infectious diseases, in the light of the latest discoveries. Water and milk and other foods are tested for the presence of disease germs; cases of disease are quarantined; and innumerable provisions, unthought of fifty years ago, are now practised daily for the maintenance of the health of the people.

In the city of New York the Department of Health now undertakes, free of charge, examinations for the diagnosis of malaria, diphtheria, tuberculosis, typhoid fever and rabies. It treats all cases of rabies by the Pasteur method free of charge, and it supplies, at slight cost, diphtheria antitoxin and vaccine virus, besides mallein to aid in the diagnosis of glanders in horses, and tuberculin for similar use with suspected tuberculosis in cattle. Moreover, from time to time it issues circulars, intended for the education of physicians regarding the causation of infectious diseases and the newest methods of treatment; and through its officers and other physicians and by means of printed matter it endeavors to educate the people in matters of private sanitation. It requires official notification by public institutions and physicians of all cases, not only of the epidemic diseases, but even of tuberculosis. The benefits derived from these various prophylactic measures are seen in great decrease in mortality from the diseases in question. Much good is expected from the work of the newly organized Committee on the Prevention of Tuberculosis of the Charity Organization Society of New York, which, backed by financial resources, is about to undertake an active campaign to lower the death rate from this particular disease, and to lessen the suffering and distress attributable to it.

Fifty years ago the term preventive medicine was unknown. To-day it represents a great body of well-attested and accepted principles. It has cleaned our streets, it has helped to build our model tenements, it has purified our food and our drinking water, it has entered our homes and kept away disease, it has prolonged our lives, and it has made the world a sweeter place in which to live.

Serum Therapy.—But if the ounce of prevention has not been applied or has failed, and the bacteria have forced an entrance into the body, what can scientific medicine do to cure? Two things are possible—the destruction of the destructive germs, and the neutralization of their poisonous toxins. The commonly recognized drugs here prove inefficient, for the simple reason that the amount of the drug sufficient to kill the bacteria is so great as to endanger the life of the patient. The most promising line of treatment has been suggested by the results of a study of the mutual relations of the bacteria and their hosts. Here again there are many gaps in our knowledge. It is not surprising that the cells of the body resent the intrusion of the barbaric horde of microorganisms, with their poisonous offscourings. The cells are roused to unwonted activity, and pour forth into the blood specific substances, which, in many cases at least, seem to be of two distinct kinds, the *cytolysins* and the *antitoxins*. Of these, the cytolysins are destructive to the invading bacteria, while the antitoxins are capable of neutralizing, though in a manner not wholly clear, the toxic products of bacterial growth. Cytolysins oppose the bacteria, while antitoxins oppose the bacterial toxins, and the outcome of the disease depends on the relative efficiencies of the contending forces. If the invaders prove too powerful for the body cells, the individual succumbs; if the defenders prevail, he recovers.

With the picture of this natural conflict before the mind, medical science asked: 'Is it not possible to aid the invaded body by providing it with weapons of the same kind as its own, but in larger quantity?' This question medical science has answered emphatically and affirmatively in the case of two serious diseases, diphtheria and tetanus, or lockjaw. By making a pure culture of their germs, and injecting their toxins into the bodies of animals, it can obtain a blood serum heavily charged with antitoxin. This when injected into the diseased human body supplements the antitoxin there found, and by so much the patient is aided in his struggle. With both these diseases the success of the serum treatment has been pronounced. A recent study of 200,000 cases in which the antitoxin of diphtheria was used shows the fatality from that disease to be reduced from 55 to 16 per cent. The problems presented by other infectious diseases seem to be more difficult. What seems to be required in most cases is a serum containing in quantity rather the cytolytic than the antitoxic substance, and as yet an efficient serum of this nature has not been found. Any day may yield such an one. But the matter of the relation of cytolysins and antitoxins, and their respective efficiencies in specific diseases, needs much elucidation. Serum therapy is in its infancy, but its methods appear so rational that it seems destined to develop into a most efficient branch of scientific medicine.

Second only in importance to the cure is the prevention of a future attack of the disease, or, in other words, the conferring of immunity on the individual. The disease itself, when running its natural course within an individual, confers a natural immunity against a subsequent attack, and with many diseases this may prove to be a life-long protection. Typhoid fever and smallpox, for example, rarely attack the individual a second time. In its present state the serum treatment also accomplishes immunity in some, though slight, degree, but greater and more lasting efficiency is desired. Probably no problem in bacteriology is being attacked more vigorously and more widely at the present time than this. A suggestive hypothesis by Ehrlich as to the chemical relations of the invading cells and the cells of the body has stimulated investigations in many laboratories, and both the nature of immunity and the best method of accomplishing it, which have puzzled medicine so long, bid fair to become known in the near future. With this achieved, preventive medicine will have gained one of its greatest triumphs.

A word should here be said regarding two of the infectious diseases whose peculiar method of transmission, long a mystery, has now become known. I refer to malaria and yellow fever. The able work of Laveran, Manson, Ross, Grassi, Koch and others on the former, and that of Reed and other courageous Americans on the latter, have demonstrated conclusively that these diseases are transmitted from man to man through the aid of the mosquito, which, receiving the germ from an infected individual, cultivates it within its own body and later delivers it in a properly prepared form to another unfortunate human being. Moreover, it is entirely probable that this is the sole method of the transmission of these diseases. The ounce of prevention here consists in: first, eliminating from the community, so far as possible, the breeding places of the mosquito; secondly, totally preventing, by simple screens, the access of the insect to each case of the disease. By the employment of these simple methods in Havana, during the year ending with the end of last September, not a single case of yellow fever originated within the city, an event unparalleled in recent times. The active work now being carried on by the Liverpool School of Tropical Medicine on the west coast of Africa bids fair to reduce materially the extent of malarial fever, so long the scourge of that region.

It is impossible to predict the full outcome, in the future, of the diligent research of the past few decades in the field of the infectious diseases. Certain it is, that in civilized countries there appear no more the terrible epidemics of the past, such as the Black Death, which, in the fourteenth century, ravaged much of the continent of Europe, and in England swept away more than half a population of three or four millions. The struggle of the deadly germs for existence is becoming daily a more desperate one. Just as paleontology has revealed numerous instances of the annihilation of once flourishing species of organisms high in the scale of life, it is perhaps not visionary to look forward to the ultimate extinction of these more lowly forms, and, with them, to the abolishment forever from the face of the earth of the diseases which they cause.

The study of the microorganisms in the past and present bears upon a much wider range of subjects than the immediately practical one of the prevention and cure of individual diseases, however important that may be. It is constantly aiding, in ways surprising and unforeseen, in the solution of even long-standing and remote problems. I need only mention here that of the recognition of human blood as distinguished from that of lower animals. Moreover, this study has helped in the elucidation of many of the fundamental problems of protoplasmic activity, and has given men of medicine a broader culture and a higher outlook over the accomplishments and possibilities of the human organism. This cannot fail to react upon other fields than that of the infectious diseases, to make treatment in general a more rational matter than it has ever been, and to uplift the whole science of medicine.

Before finally leaving this subject, I would speak of the many instances of personal heroism exhibited by the men who have labored in this field. The records teem with stories of those who, recognizing more fully and intelligently than others the dangers that surrounded them, and the deadly risks they were incurring, have, nevertheless, led by their great courage and scientific devotion, gone steadily forward, sometimes to death itself. There is danger in the laboratory and the hospital, and greater danger in the midst of epidemics. 'What does it matter?' replied Pasteur when his friends spoke of these perils, 'Life in the midst of danger is *the* life, the real life, the life of sacrifice, of example, of fruitfulness,' and he continued his labors. The death from cholera of a devoted and much-loved pupil of his at Alexandria, whither he had voluntarily gone to investigate the dread scourge of 1883, was a great grief to the master, but only intensified his devotion to his work. Since then many others have met an end as heroic, martyrs to the cause of medical progress. Among these I need only mention our own Lazear, who gave up his life in the yellow-fever laboratories in Cuba. Notwithstanding such tragedies, the laboratories and hospitals are always full of workers, and each new epidemic finds those who are eager to go to the scene to aid. The good to be performed and the honors to be won overcome the fears, and the ranks of laborers in this most deadly province of scientific medicine are never wanting in men.

Internal Secretion.—Leaving the subject of the infectious diseases, let me turn now to a mode of treatment based on recent experimental work, and applied successfully to certain unusual and grave maladies, which are evidently accompanied by disordered nutrition, but the cause and proper treatment of which until very recently were obscure.

About a dozen years ago the phrase 'internal secretion' began to be employed in physiological laboratories for the first time, and for a newly recognized function of glandular organs. It was well known that glands receive from the blood raw material, and manufacture from it specific secretions, which are discharged either outside the body for excretion, as is the case with the perspiration, or to the surface of mucous membranes for use in bodily function, as instanced by the gastric juice. It was discovered, however, that certain glands, such as the thyroid, the suprarenal, the pancreas and others, manufacture and return to the blood specific substances, differing with the different glands, but of important use to the body, and the absence of which leads to profound consequences. These substances were called *internal secretions.* Thus, removal or suspension of the function of the thyroid gland, and hence the loss of its internal secretion, reduces the body to a serious pathological state, long recognized by the name myxedema. Of similar causation is the peculiar condition, called cretinism, which is characterized by a physical and mental stunting of the growing individual. The rare Addison's disease is associated with disturbance of the function of the suprarenal glands; and other instances might be mentioned. It seemed a simple step from the discovery of the cause to the discovery of a cure. If absence of a substance is the cause of a disease, supplying that substance ought to effect a cure, and such was found to be the case. Administering to the afflicted individual the fresh thyroid gland of animals or a properly prepared extract of such gland, was found to alleviate or cure myxedema; and other instances of the efficiency of glandular products were recorded. So striking were the facts that active investigation of the matter was undertaken, with the result of showing that the chemical interrelationships of the various tissues of the body were profound, and a knowledge of them of exceeding value to the physician. As a possible instance of this may be mentioned the idea, recently suggested by Professor Herter, of New York, that the suprarenal gland, by means of its internal secretion may control the manufacture of sugar by the cells of the pancreas, an idea which, if proved true, may bear significantly on the causation and treatment of diabetes. There is need of much research in this field of the internal secretions, but already glandular extracts have proved a valuable addition to the remedies of the scientific physician.

Brain Surgery.—I have already spoken of the entire change in the methods of general surgery during a period of twenty-five years, owing to the rise of bacteriology. But I ought to mention specifically the remarkable advance made during the same time in the surgical treatment of diseases of the central nervous system, the brain and the spinal cord, for it is here that the scientific method has achieved one of its most complete triumphs.

Although it was pointed out by the French surgeon, Broca, as early as 1861, that the loss of the power of speech is associated with disease of a certain portion of the left hemisphere of the brain, it was still the general belief that the acting brain acts as a whole. This idea prevailed until 1870, when the German physiologists, Fritsch and Hitzig, demonstrated that stimulation of different areas of the cerebral surface evoke in the body different movements. This was the beginning of the experimental investigation of *cerebral localization,* a line of research which has proved rich in results. The brain is not one organ acting as a whole, but an association of many organs, each with its specific duty to perform, but intricately associated with all the others. In the years that have passed since the discovery of Fritsch and Hitzig it has been the task of neurologists to discover the functions of the different parts of the central nervous system, to unravel their intricate interconnections, and to associate the disturbance of their functions with external symptoms in the individual. As a result of this labor the neurologist, after a careful study of his patient, now says to the surgeon, 'Cut there, and you will find the disturbing agent'—and the brilliant success of the brain surgery of the present day justifies its scientific basis.

The New Physical Chemistry.—In the early part of this address I spoke of the freedom with which medicine made use of discoveries in other sciences than its own. A very recent striking illustration of this is that of the application of the principles of the new physical chemistry to the phenomena of the living body. From the standpoint of physical chemistry the body may be regarded as a mass of minute particles of semi-liquid living substance, the protoplasmic cells, each surrounded by a thin permeable membrane, the cell-wall, and bathed externally by the circulating liquids, the blood and lymph. Both the protoplasm and the external liquid contain substances in solution, and whatever passes between them, be it food, or waste, or drug, must pass in the form of a solution through the intervening cell-wall. The laws of solutions and the laws of the passage of solutions through membranes must hence find their applications in the body. It has been the general belief that when a substance becomes dissolved its molecules remain intact, and are merely separated from one another by the water or other solvent. Quite recently physical chemistry has shown that this view is not altogether correct, but that a varying amount of disintegration takes place, a dissociation of the molecules into their constituent atoms or groups of atoms. Moreover, these dissociated particles, *ions,* as they have been called, are charged with electricity; some, the *kations,* charged positively; others, the *anions,* negatively. Electrolytic dissociation is much more pronounced in solutions of inorganic than of organic substances. In proportion to its extent, specific properties are conferred on these solutions. What these properties are is not altogether clear, but it is entirely probable that the specific properties of many drugs are dependent, in part at least, on the amount of their dissociation when in solution. Furthermore, the amount of a given substance which is able to pass through a membrane is measured by the so-called *osmotic pressure* of the substance, and this, which varies with the concentration of the solution, seems to depend on the movements of the molecules and the ions within the liquid solvent. Since the physician, in the giving of a drug, wishes to induce certain cells of the body of his patient to absorb certain quantities of the drug, it is obvious that a knowledge of the principles by which substances pass through membranes will aid him.

The laws of solutions and the laws of osmosis still remain largely obscure, and because of this the literature of the subject contains much that is of little value—deductions from insufficient data, conclusions of one day which are overthrown by the researches of the next, fantastic imaginings which only throw discredit on the really worthy, and hopes buoyed up by the light of an *ignis fatuus.* But enough of truth has been already revealed to stimulate active research for the sake of physiological progress, and to show that the subject bears profoundly on the problems which the physician meets daily. It is partly along this line that the revitalized science of pharmacology, the study of the physiological action of drugs, which for several years has been actively pressing to the front, promises to make still more rapid progress in the near future.

Medical Schools.—The growth of scientific medicine, some of the branches of which I have thus tried to present to you, has reacted powerfully on our medical schools. The prominent features of this reaction are: the increase in the requirements for admission, the greater amount of laboratory and clinical instruction, the extension of the course in length, and the inclusion of the medical schools within universities.

Within a few years the requirements for admission to medical study have been raised from an elementary education, by many schools to that of a high-school course or college preparation, by a few to a partial college training, and by two to a full college course with a resulting bachelor's degree. As the wisdom of the latter is still not generally conceded, it is doubtful whether in the near future it will become widespread. Ideal as it seems, the one argument against it, that thereby the young man is forced to delay entrance to his life-work until a late age, has never been satisfactorily answered. President Butler's recent pronouncement in favor of a division of the college work into a two-year and a four-year course has much in its favor. This would allow a certain amount of those studies which are pursued for the purpose of general education and culture, and a grounding in the especially necessary chemistry, physics and biology.

The increase in the amount of laboratory and clinical instruction is merely in harmony with the truth that seeing is believing. 'Study nature, not books,' says Agassiz, and he might have added for the guidance of the teacher, 'Weary not your pupils with words, let them see things.'

In length the medical course has rapidly increased from two to three, and from three to four, years. With the increase in the number of hospitals throughout the land, and the opportunities offered therein to recent graduates to serve as internes under competent visiting physicians, one or two years more may be added to the student's equipment, making a training of five or six years before the young doctor actually begins independent practice.

The inclusion of the medical schools within universities is one of the most important advances of medical education made in many years. Of the 156 schools existing in this country, 74, or nearly one half, are departments of colleges or universities. In this respect, however, America is still far behind Germany, for in the latter country no medical school exists except as a part of the larger institution. The advantages of such a connection are too obvious to dwell upon. Apart from the material benefits that are likely to accrue to the school, and the prestige granted it in the educational world, there is the atmosphere of a higher culture, a more scientific spirit, and less utilitarianism, which is breathed by instructors and students alike, and which cannot fail to make the graduates broader men. In the larger of these university schools a portion of the teaching body consists of men who do not engage in medical practice, but, like the instructors in the non-professional schools of the university, give their whole time to their specialties, in teaching and research. Usually these are the holders of the chairs of the non-clinical, basal sciences, anatomy, physiology, pathology, bacteriology, physiological chemistry and pharmacology. The outcome of this must be to broaden and deepen the scientific basis of medicine. The clinical branches are still taught by men who are at the same time private practitioners. In a recent thoughtful essay on 'Medicine and the Universities,' a professor in one of our leading medical schools urges the further severance of medical teaching and private medical practice. He would have internal medicine, surgery, obstetrics, and, indeed, all the principal clinical departments of instruction, placed like the fundamental sciences 'on a true university basis,' by which he means that the holders of these chairs should devote all their time and energy to teaching and research. This would require the paying of large salaries and the building of extensive university hospitals, wherein the professors could carry on their investigations. In my opinion the benefits that would thus accrue to scientific medicine far outweigh the arguments that may be brought against so radical a change, and, notwithstanding its highly idealistic character, in view of the present unparalleled generosity of private wealth in endowing scientific research, the present rapid and sure progress of medicine, and the intimate connection of medical advance with the interests of all classes, I look forward confidently to the future establishment of our medical schools on a basis more nearly parallel with that of the non-professional schools of the university.

What now as to the future of medical science? With the impetus which it has received from the mighty strides of the past twenty-five years, its future progress and future great achievements are assured. But it behooves us, in whose hands lies the training of the physician, to see that he enter on his work with a full realization of his responsibilities. *The future of scientific medicine lies with the university.* "Though the university may dispense with professional schools," said President Wilson in his inaugural address at Princeton a few weeks ago, "professional schools may not dispense with the university. Professional schools have nowhere their right atmosphere and association, except where they are parts of a university and share its spirit and method. They must love learning as well as professional success, in order to have their perfect usefulness.'' The perfect usefulness of the professional school consists, not merely in teaching our embryo physician how to destroy bacteria, to remove tumors, or to calm the fire of fevers. These things he must understand, and these he must do daily for the suffering individual. But beyond these are larger tasks. The physician's should be a life of service and of leadership combined. He serves well when he relieves suffering; still better when he teaches men how to live; but he serves best of all when he pushes out into the unknown and makes medical science the richer for what he contributes to it. The knowledge of wise men, the deeds of diligent men and the valor of heroes are the gift of those who have preceded him. Let us see to it that he pass on this heritage, augmented, to those who follow.

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HISTORIES AND BIBLIOGRAPHIES OF PHYSICS.

THE study of the science of physics, like that of any other of the expressions of activity of the human mind, may be approached from two different points of view. First, the attention may be confined to the study of phenomena and of the inductions based upon them. These inductions are seen to lead to what are called laws of physics. From the method of their establishment it is evident that these laws are but résumés of physical experience—they are classifications of phenomena according to some principle of analogy. The study of physics is usually approached in this way—a way which is open to the very serious objection that the student is very apt to think that the principles or laws with which he becomes familiar are laws in the judicial sense and not mere résumés of experience in the formation of which the mind which makes the résumé also plays a part. This must be evident to any one who considers the nature of classification and induction. There is always behind the induction, in the mind of the man who makes it, some idea or principle upon which the classification is based.

In the second place the science of physics may be studied as if it were a vital organism. We say without hesitation that this science grows and develops—expressions in which it is tacitly agreed that we are dealing with a living organism, for what grows and develops must surely have life in some form. We may then fairly put the question, 'In what does the life of science consist?' The answer to this question seems to me to be 'In the ideas and conceptions upon which the inductions and classifications of the science are based.' Examples may help to make this clear. Ptolemy explained the solar system upon one set of ideas, Copernicus on another. Sir Isaac Newton deduced the laws of optics with the help of certain conceptions of rapidly moving particles of matter. Young and Fresnel classified those same observed phenomena upon the basis of ideas of waves in an elastic medium. Faraday and Maxwell resumed the same experimental facts by conceiving them to be manifestations of electric and magnetic forces. The development in these sciences is thus seen to consist in the changes in the conceptions and ideas which lie at the basis of the classifications and inductions which lead to scientific laws. Hence if we would study science as if it were a living organism we must investigate the ideas which are back of it and which form its real life.

When studied in this latter way it will be found that the science of physics is not an isolated subject in the thought of man-