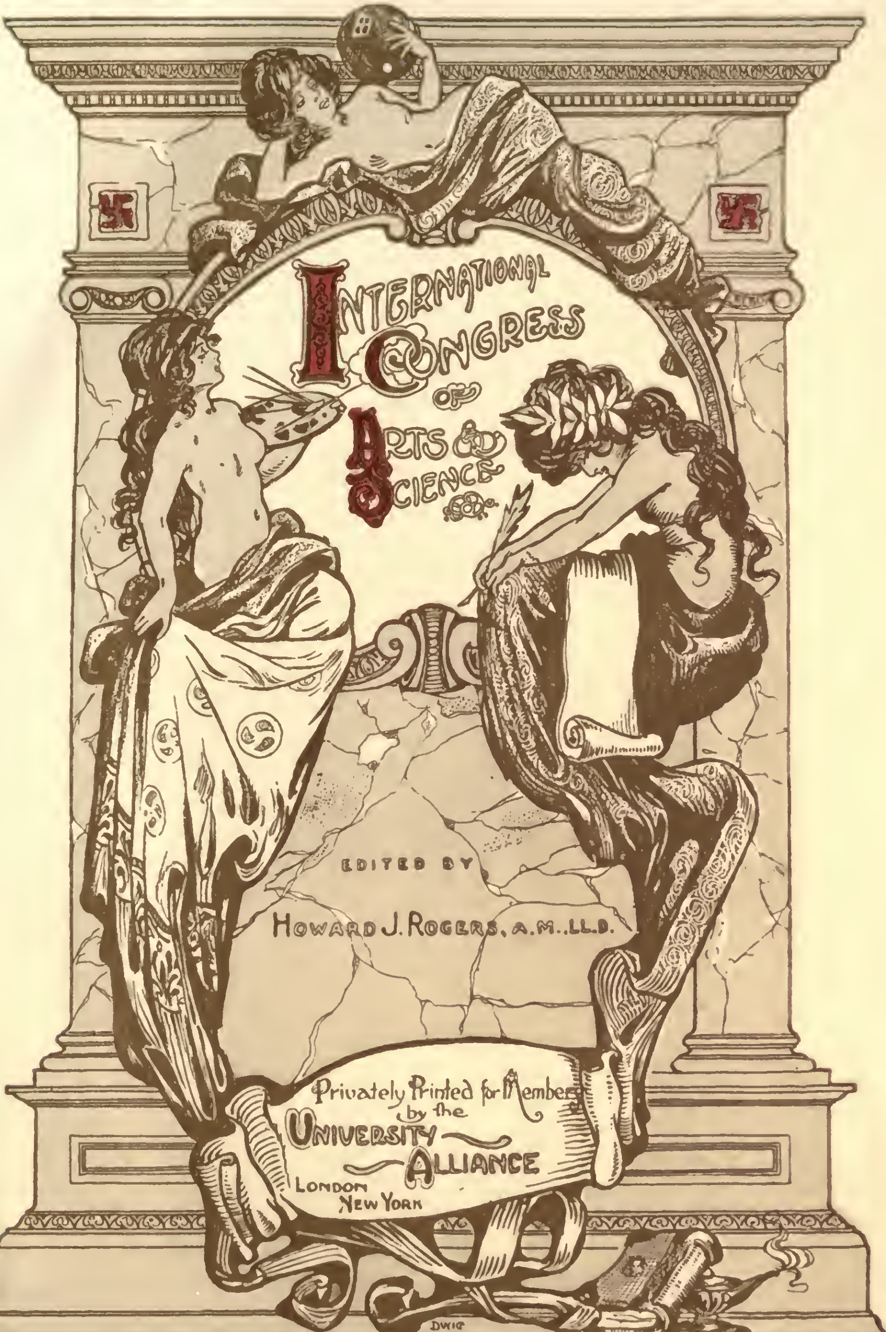
INTERNATIONAL CONGRESS OF ARTS & SCIENCE
EDITED BY
HOWARD J. ROGERS, A.M., LL.D.
Privately Printed for Members by the
UNIVERSITY ALLIANCE
LONDON
NEW YORK
DWIG

OF THE

Cambridge Edition

There have been printed seven hundred and fifty sets

of which this is copy

No. 3

INTERNATIONAL CONGRESS OF ARTS AND SCIENCE

JOAN OF ARC LISTENING TO THE VOICE

Photogravure from the Painting by François Léon Benouville.

According to a prophecy by Merlin, which was current in the native province of Joan of Arc, France was to be overwhelmed with calamities, but was to be delivered by a virgin out of the forest of Domremy. Joan, who was undoubtedly familiar with the prophecy, imagined that she heard supernatural voices commanding her to liberate France. This is the romantic theme of Benouville's great painting.

INTERNATIONAL CONGRESS
OF
ARTS AND SCIENCE

EDITED BY

HOWARD J. ROGERS, A.M., LL.D.
DIRECTOR OF CONGRESSES

VOLUME XI

MEDICINE

COMPRISING

Lectures on Public Health, Preventive Medicine, Pathology, Therapeutics and Pharmacology, Neurology, Psychiatry, History of Surgery, and Development of Modern Medicine

UNIVERSITY ALLIANCE
LONDON NEW YORK

ILLUSTRATIONS

VOLUME XI

TABLE OF CONTENTS

VOLUME XI

TABLE OF CONTENTS

DIVISION E—UTILITARIAN SCIENCES

GROUP OF SCIENTIFIC LECTURERS

The International Congress of Arts and Science presents men renowned in almost every branch of Science, leading professors of the greatest institutions of learning, astronomers, surgeons, technologists, economists, pathologists, analogists, physicists—famous specialists and scientists from all quarters of the globe.

The present group includes a number of these celebrities. In the front row, from left to right, we have the full-length portraits of Prof. J. G. Hagen, S.J., of the Georgetown University, which was founded by the Jesuits in 1788; Dr. Carl Beck, Professor of Surgery in the New York Post-Graduate Medical School; Dr. Wilhelm Waldeyer, Professor of Anatomy, University of Berlin; Dr. Simon Newcomb, President of the Congress and Dean of American Scientists; Dr. Oscar Backlund, Astronomer of the Imperial Academy of Science, St. Petersburg; Dr. Ormond Stone, Professor of Astronomy, University of Virginia; and Dr. David Starr Jordan, President of Leland Stanford, Jr., University, in California. In the second row on the extreme left, we have the portrait of Dr. Benjamin Ide Wheeler, President of the University of California, and on the extreme right stands Dr. Eugen von Philippovich, Professor of Political Economy, University of Vienna.

DIVISION E — UTILITARIAN SCIENCES

DIVISION E — UTILITARIAN SCIENCES

(*Hall* 1, *September* 20, 10 *a. m.*)

SPEAKER: PRESIDENT DAVID STARR JORDAN, Leland Stanford, Jr., University.

UTILITARIAN SCIENCE

BY DAVID STARR JORDAN

[**David Starr Jordan**, President of Leland Stanford, Jr., University since 1891. b. January 19, 1851, Gainesville, Wyoming County, New York. M.S. Cornell, 1872; LL.D. *ibid.* 1886; Ph.D. Butler University, 1880; M.D. University of Indiana, 1875; Post-Graduate, Harvard University, London, Paris. Professor of Biology, Butler University, 1875–79; Professor of Zoölogy, University of Indiana, 1879–85; President of Indiana University, 1885–91; Associate of the U. S. Fish Commission since 1878; Head of Bering Sea Commission, 1896–98; President of California Academy of Sciences; Fellow of A. O. U.; Member of American Philosophical Society, etc. **Author of many books, including** *Fishes of Northern and Middle America; Science Sketches; Manual of the Vertebrates; Guide to Study of Fishes; The Innumerable Company, Care and Culture of Men; The Voice of the Scholar*, etc.]

It falls to my lot to-day, to discuss very briefly, in accordance with the Programme of this Congress, some of the common features of utilitarian science, with a word as to present and future lines of investigation or instruction in some of those branches of the applications of knowledge which have been assigned to the present division.

Applied science cannot be separated from pure science; for pure science may develop at any quarter the greatest and most unexpected economic values; while on the other hand, the application of knowledge must await the acquisition of knowledge before any high achievement can be reached. For these reasons, the classification adopted in the present Congress, or any other classification of sciences into utilitarian science and other forms of science, must be incomplete and even misleading. Whatever is true is likely some time to prove useful, and all error is likely to prove some time disastrous. From the point of view of the development of the human mind, all truth is alike useful, and all error is alike mischievous.

In point of development, pure science must precede utilitarian science. Historically, this seems to be not true; for the beginnings of science in general, as alchemy, astrology, and therapeutics, seem to have their origin in the desire for the practical results of knowledge. Men wanted to acquire gold, to save life, to forecast the future, not for knowledge's sake, but for the immediate results of success in these directions. But even here accurate knowledge must precede any success in its application, and accuracy of knowledge is all that we mean by pure science. Moreover, as through the ages the representatives of the philosophies of the day, the *a priori* explanations of the universe, were bitterly and personally hostile to all inductive conclusions based on the study of base matter, men of science were forced to disguise their work under a utilitarian cloak. This is more or less true even to this day, and the greatest need of utilitarian science is still, as a thousand years ago, that this cloak should be thrown off, and that a larger and stronger body of workers in pure science should be developed to give the advance in real knowledge on which the thousands of ingenious and noble applications to utilitarian ends must constantly depend.

It is a fundamental law of psychology that thought tends to pass over into action. Applied science is knowledge in action. It is the flower of that highest philanthropy of the ages by which not even thought exists for itself alone, but must find its end in the enlargement of human control over matter and force or the amelioration of the conditions of human life.

The development of all science has been a constant struggle, a struggle of fact against philosophy, of instant impressions against traditional interpretations, of truth against "make-believe." For men are prone to trust a theory rather than a fact; a fact is a single point of contact; a theory is a circle made of an infinite number of points, none of them, however, it may be, real points of contact.

The history of the progress of science is written in human psychology rather than in human records. It is the struggle of the few realities or present sense-impressions against the multitude of past impressions, suggestions, and explanations. I have elsewhere said that the one great discovery of the nineteenth century — forestalled many ages before — was that of the reality of external things. Men have learned to trust a present fact or group of facts, however contradictory its teachings, as opposed to tradition and philosophy. From this trust in the reality of the environment of matter and force, whatever these may be, the great fabric of modern science has been built up. Science is human experience of contact with environment tested, set in order, and expressed in terms of other human experience. Utilitarian science is that part of all this knowledge which we can use in our lives, in our business. What is pure science to one is applied science to another. The investigation of the laws of heredity may be strictly academic to us of the university, but they are utilitarian as related to the preservation of the nation or to the breeding of pigs. In the warfare of science the real in act and motive has been persistently substituted for the unreal. Men have slowly learned that the true glory of life lies in its wise conduct, in the daily act of love and helpfulness, not in the vagaries fostered by the priest or in the spasms of madness which are the culmination of war. To live here and now as a man should live constitutes the ethics of science, and this ideal has been in constant antithesis to the ethics of ecclesiasticism, of asceticism, and of militarism.

The physical history of the progress of science has been a struggle of thinkers, observers, and experimenters against the dominant forces of society. It has been a continuous battle, in which the weaker side, in the long run, is winner, having the strength of the earth behind. It has been incidentally a conflict of earth-born knowledge with opinions of men sanctioned by religion; of present fact with preëstablished system, visibly a warfare between inductive thought and dogmatic theology.

The real struggle, as already indicated, lies deeper than this. It is the effort of the human mind to relate itself to realities in the midst of traditions and superstitions, to realize that nature never contradicts herself, is always complex, but never mysterious. As a final result all past systems of philosophy, perhaps all possible systems, have been thrown back into the realm of literature, of poetry, no longer controlling the life of action, which rests on fact.

This conflict of tendencies in the individual has become a conflict among individuals as each is governed by a dominant impulse. The cause of tradition becomes that of theology; — for men have always claimed a religious sanction for their own individual bit of cosmic philosophy. Just as each man in his secret heart, the centre of his own universe, feels himself in some degree the subject of the favor of the mysterious unseen powers, so does society in all ages find a mystic or divine warrant for its own attitude towards life and action, whatever that may be.

The nervous system of man, inherited from that of the lower animals, may be regarded as primarily a means of making locomotion safe. The reflex action of the nerve centre is the type of all mental processes. The sensorium, or central ganglion, receives impressions from the external world representing, in a way, various phases of reality. The brain has no source of knowledge other than sensation. All human knowledge comes through human experience. The brain, sitting in darkness, has the primary function of converting sensory impressions into impulses to action. To this end the motor nerves carry impulses outward to the muscles. The higher function of nerve-action, which we call the intellect, as distinguished from simple reflex action and from instinct, is the choice among different responses to the stimulus of external realities. As conditions of life become more complex, the demands of external realities become more exacting. It is the function of the intellect to consider and of the mind to choose. The development of the mind causes and permits complexity in external relations. Safety in life depends on choosing the right response to external stimulus. Wrong choice leads to failure or to death.

From the demands of natural selection results the intense practicality of the mental processes. Our senses tell us the truth as to external nature, in so far as such phases of reality have been essential to the life of our ancestors. To a degree, they must have seen "things as they really are," else they should not have lived to continue the generation. Our own individual ancestors through all the ages have been creatures of adequate accuracy of sensation and of adequate power of thought. Were it not so they could not have coped with their environment. The sensations which their brains translated into action contained enough of absolute reality to make action safe. That our own ordinary sensations and our own inductions from them are truthful in their essentials, is proved by the fact that we have thus far safely trusted them. Science differs from common sense mainly in the perfection of its tools. That the instruments of precision used in science give us further phases of reality is shown by the fact that we can trust our lives to them. We find it safer to do so than to trust our unaided senses.

While our senses tell us the truth as to familiar things, as rocks and trees, foods and shelter, friends and enemies, they do not tell us the whole truth: they go only so far as the demands of ancestral environment have forced them to go. Chemical composition our senses do not show. Objects too small to handle are too small to be seen. Bodies too distant to be reached are never correctly apprehended. Accuracy of sense decreases as the square of the distance increases. Sun and stars, clouds and sky, are in fact very different from what they seem to the senses.

In matters not vital to action, exactness of knowledge loses its importance. Any kind of belief may be safe, if it is not to be carried over into action. It is perfectly safe, in the ordinary affairs of life, for one who does not propose to act on his convictions to believe in witches and lucky stones, imps and elves, astral bodies and odic forces. It is quite as consistent with ordinary living to accept these as objective realities as it is to have the vague faith in microbes and molecules, mahatmas and protoplasm, protective tariffs and manifest destiny, which forms part of the mental outfit of the average American citizen to-day. Unless these conceptions are to be brought into terms of personal experience, unless in some degree we are to trust our lives to them, unless they are to be wrought into action, they are irrelevant to the conduct of life. As they are tested by action, the truth is separated from the falsehood, and the error involved in vague or silly ideas becomes manifest. As one comes to handle microbes, they become as real as bullets or oranges and as susceptible of being manipulated. But the astral body covers only ignorance and ghosts vanish before the electric light.

Memory-pictures likewise arise to produce confusion in the mind. The record of past realities blends readily with the present. Men are gregarious creatures and their speech gives them the power to add to their own individual experiences the concepts and experiences of others. Suggestion and conventionality play a large part in the mental equipment of the individual man.

About the sense-impressions formed in his own brain each man builds up his own subjective universe. Each accretion of knowledge must be cast more or less directly in terms of previous experience. By processes of suggestion and conventionality the ideas of the individual become assimilated to those of the multitude. Thus myths arise to account for phenomena not clearly within the ordinary experiences of life. And in all mythology the unknown is ascribed not to natural forces, but to the action of the powers that transcend nature, that lie outside the domain of the familiar and the real.

It has been plain to man in all ages that he is surrounded by forces stronger than himself, invisible and intangible, inscrutable in their real nature, but terribly potent to produce results. He cannot easily trace cause and effect in dealing with these forces; hence it is natural that he should doubt the existence of relations of cause and effect. As the human will seems capricious because the springs of volition are hidden from observation, so to the unknown will that limits our own we ascribe an infinite caprice. All races of men capable of abstract thought have believed in the existence of something outside themselves whose power is without human limitations. Through the imagination of poets the forces of nature become personified. The existence of power demands corresponding will. The power is infinitely greater than ours; the sources of its action inscrutable: hence man has conceived the unknown first cause as an infinite and unconditioned man. Anthropomorphism in some degree is inevitable, because each man must think in terms of his own experience. Into his own personal universe, all that he knows must come.

Recognition of the hidden but gigantic forces in nature leads men to fear and to worship them. To think of them either in fear or in worship is to give them human forms.

The social instincts of man tend to crystallize in institutions even his common hopes and fears. An institution implies a division of labor. Hence, in each age and in each race men have been set apart as representatives of these hidden forces and devoted to their propitiation. These men are commissioned to speak in the name of each god that the people worship or each demon the people dread.

The existence of each cult of priests is bound up in the perpetuations of the mysteries and traditions assigned to their care. These traditions are linked with other traditions and with other mystic explanations of uncomprehended phenomena. While human theories of the sun, the stars, the clouds, of earthquakes, storms, comets, and disease, have no direct relation to the feeling of worship, they cannot be disentangled from it. The uncomprehended, the unfamiliar, and the supernatural are one and the same in the untrained human mind; and one set of prejudices cannot be dissociated from the others.

To the ideas acquired in youth we attach a sort of sacredness. To the course of action we follow we are prone to claim some kind of mystic sanction; and this mystic sanction applies not only to acts of virtue and devotion, but to the most unimportant rites and ceremonies; and in these we resent changes with the full force of such conservatism as we possess.

It is against limited and preconceived notions that the warfare of science has been directed. It is the struggle for the realities on the part of the individual man. Ignorance, prejudice, and intolerance, in the long run, are one and the same thing. In some one line, at least, every lofty mind throughout the ages has demanded objective reality. This struggle has been one between science and theology only because theological misconceptions were entangled with crude notions of other sorts. In the experience of a single human life there is little to correct even the crudest of theological conceptions. From the supposed greater importance of religious opinions in determining the fate of men and nations, theological ideas have dominated all others throughout the ages; and in the nature of things, the great religious bodies have formed the stronghold of conservatism against which the separated bands of science have hurled themselves, seemingly in vain.

But the real essence of conservatism lies not in theology. The whole conflict, as I have already said, is a struggle in the mind of man. From some phase of the warfare of science no individual is exempt. It exists in human psychology before it is wrought in human history. There is no better antidote to bigotry than the study of the growth of knowledge. There is no chapter in history more encouraging than that which treats of the growth of open-mindedness. The study of this history leads religious men to avoid intolerance in the present, through a knowledge of the evils intolerance has wrought in the past. Men of science are spurred to more earnest work by the record that through the ages objective truth has been the final test of all theories and conceptions. All men will work more sanely and more effectively as they realize that no good to religion or science comes from " wishing to please God with a lie."

It is the mission of science to disclose — so far as it goes — the real nature of the universe. Its function is to eliminate, wherever it be found, the human equation. By methods of precision of thought and instruments of precision of observation and experiment, science seeks to make our knowledge of the small, the distant, the invisible, the mysterious, as accurate, as practical, as our knowledge of common things. Moreover, it seeks to make our knowledge of common things accurate and precise, that this accuracy and precision may be translated into action. For the ultimate end of science as well as its initial impulse is the regulation of human conduct. Seeing true means thinking right. Right thinking means right action. Greater precision in action makes higher civilization possible. Lack of precision in action is the great cause of human misery; for misery is the inevitable result of wrong conduct. "Still men and nations reap as they have strewn."

A classic thought in the history of applied science is expressed in these words of Huxley: "There can be no alleviation of the sufferings of man except in absolute veracity of thought and action and a resolute facing of the world as it is." "The world as it is" is the province of science. "The God of the things as they are is the God of the highest heaven." And as to the sane man, the world as it is is glorious, beautiful, harmonious, and divine, so will science, our tested and ordered knowledge of it, be the inspiration of art, poetry, and religion.

Pure science and utilitarian science merge into each other at every point. They are one and the same thing. Every new truth can be used to enlarge human power or to alleviate human suffering. There is no fact so remote as to have no possible bearing on human utility. Every new conception falls into the grasp of that higher philanthropy which rests on the comprehension of the truths of science. For science is the flower of human altruism. No worker in science can stand alone. None counts for much who tries to do so. He must enter into the work of others. He must fit his thought to theirs. He must stand on the shoulders of the past, and must crave the help of the future. The past has granted its assistance to the fullest degree of the most perfect altruism. The future will not refuse; and, in return, whatever knowledge it can take for human uses, it will choose in untrammeled freedom. The sole line which sets off utilitarian science lies in the limitation of human strength and of human life. The single life must be given to a narrow field, to a single strand of truth, following it wherever it may lead. Some must teach, some must investigate, some must adapt to human uses. It is not often that these functions can be united in the same individual. It is not necessary that they should be united; for art is long, though life is short, and for the next thousand years science will be still in its infancy. We stand on the threshold of a new century; a century of science; a century whose discoveries of reality shall far outweigh those of all centuries which have preceded it; a century whose glories even the most conservative of scientific men dare not try to forecast. And this twentieth century is but one — the least, most likely — of the many centuries crowding to take their place in the line of human development. In each century we shall see a great widening of the horizon of human thought, a great increase of precision in each branch of human knowledge, a great improvement in the conditions of human life, as enlightenment and precision come to be controlling factors in human action.

In the remaining part of this address I shall discuss very briefly some salient features of practice, investigation, and instruction in those sciences which in the scheme of classification of this Congress have been assigned to this division. In this discussion I have received the invaluable aid of a large number of my colleagues in scientific work, and from their letters of kindly interest I have felt free to make some very interesting quotations. To all these gentlemen (a list too long to be given here) from whom I have received aid of this kind, I offer a most grateful acknowledgment.

Engineering

The development of the profession of engineering in America has been the most remarkable feature of our recent industrial as well as educational progress. In this branch of applied science our country has come to the very front, and this in a relatively short time. To this progress a number of distinct forces have contributed. One lies in the temperament of our people, their native force, and their tendency to apply knowledge to action. In practical life the American makes the most of all he knows. Favoring this is the absence of caste feeling. There is no prejudice in favor of the idle man. Only idlers take the members of the leisure class seriously. There is, again, no social discrimination against the engineer as compared with other learned professions. The best of our students become working engineers without loss of social prestige of any sort. Another reason is found in the great variety of industrial openings in America, and still another in the sudden growth of American colleges into universities, and universities in which both pure and applied sciences find a generous welcome. For this the Morrill Act, under which each state has developed a technical school, under federal aid, is largely responsible. In the change from the small college of thirty years ago, a weak copy of English models, to the American university of to-day, many elements have contributed. Among these is the current of enlightenment from Germany, and at the same time the influence of far-seeing leaders in education. Notable among these have been Tappan, Eliot, Agassiz, and White. To widen the range of university instruction so as to meet all the intellectual, esthetic, and industrial needs of the ablest men is the work of the modern university. To do this work is to give a great impetus to pure and to applied science.

Two classes of men come to the front in the development of engineering: the one, men of deep scientific knowledge, to whom advance of knowledge is due, the other the great constructive engineers; men who can work in the large and can manage great enterprises with scientific accuracy and practical success. Everywhere the tendency in training is away from mere craftsmanship and towards power of administration. The demands of the laboratory leave less and less time for the shop. "Two classes of students," says a correspondent, "should be encouraged in our universities: First, the man whose scientific attainments are such that he will be able to develop new and important processes, the details of which may be directly applied. This type of man is the scientific engineer. The other is the so-called practical man, who will not only actually carry on engineering work, but may be called on to manage large enterprises. If his temperament and ability are such as to give him a thorough command of business methods and details, while he is in addition a good engineer, he will find a field of great usefulness before him on leaving the university. The university should encourage young men to undertake the general executive work necessary to handling men and in the many details of large enterprises. The successful man of this character is necessarily a leader, and the university should recognize that such a man can be of great influence in the world, if he is thoroughly and broadly educated."

"We need," says another correspondent, "men possessing a better general training than most of those now entering and leaving our engineering schools. We need more thoroughly trained teachers of engineering, men who combine theoretical training with a wide and constantly increasing experience, men who can handle the factors of theory, practice, and economics."

"Technical education," says another correspondent, "should look beyond the individual to the aggregate, and should aim to shape its activities so as to develop at the maximum number of points sympathetic and helpful relations with the industrial and engineering interests of the state. This means careful and steady effort towards the coördination of the activities of the technical school with the general condition of industry and engineering as regards its raw materials, its constructive and productive operations, its needs and demands with regard to personnel, and its actual or potential trend of progress."

The coming era in engineering is less a period of discovery and invention than of application on a large scale of principles already known. Greater enterprises, higher potentialities, freer use of forces of nature, all these are in the line of engineering progress.

"The realm of physical science," says a correspondent, "has become to the practical man a highly improved agricultural land, whereas in earlier days it was a virgin country possessing great possibilities and exacting but little in the way of economic treatment."

In all forms of engineering, practice is changing from day to day; the principles remain fixed. In electricity, for example, the field of knowledge "extends far beyond the direct limits or needs of electrical engineers."

"The best criticism as to engineering education came formerly almost entirely from professors of science and engineering. To-day the greatest and most wholesome source of such criticism comes from those engaged in practical affairs. We have begun a régime wherein coördinated theory and practice will enter into the engineering training of young men to a far greater and more profitable extent than ever before."

"The marvelous results in the industrial world of to-day," says a correspondent, "are due largely to the spirit of 'usefulness, activity, and coöperation' that exists in each community of interests and which actuates men employing the means which applied science has so bountifully accorded. I know of no greater need of engineering education in our country to-day than that its conduct in each institution should be characterized by the same spirit of usefulness, activity, and coöperation."

In mining, as in other departments of engineering, we find in the schools the same growing appreciation of the value of training at once broad, thorough, and practical, and the same preference for the university-trained engineer over the untrained craftsman.

The head of a great mining firm in London writes me that "for our business, what we desire are young men of good natural qualifications, thoroughly trained theoretically without any so-called practical knowledge unless this knowledge has been gained by employment in actual works."

On the pay-roll of this English firm I find that five men receive salaries of more than $20,000. All these are graduates of technical departments of American universities. Seventeen receive from $6000 to $20,000. Nine of these were trained in American universities, one in Australia, and two in England, while five have risen from the ranks.

In the lower positions, most have been trained in Australia, a few in England, while in positions bearing a salary of less than $2500 most have risen from the ranks.

"Given men of equal qualifications," says the director of this firm, "the man of technical training is bound to rise to the higher position because of his greater value to his employer. As a rule, also, men who have been technically trained are, by virtue of their education, men who are endowed with a professional feeling which does not to the same extent exist among those men who have risen from the rank and file. They are therefore more trustworthy, and especially in mining work, where premium for dishonesty exists, for this qualification alone they are bound to have precedence. We do not by any means wish to disparage the qualifications of many men who have risen from the ranks to eminent positions, but our opinion may be concentrated in the statement that even these men would be better men had they received a thorough technical training."

The progress of chemical engineering is parallel with that in other departments of technology. Yet the appreciation of the value of theoretical training is somewhat less marked, and in this regard our manufacturers seem distinctly behind those of Germany.

"The development of chemical industries in the past history of the United States," says a correspondent, "was seriously delayed by the usually superficial and narrow training of the chemist in the colleges. Thus managers and proprietors came to undervalue the importance of chemical knowledge. The greatest need at present in the development of chemical industries is an adequate supply of chemists of thorough training to teach manufacturers the importance in their business of adequate chemical knowledge. Epoch-making advances in chemical industry will spring from the brain of great chemists, and to insure the production of a few of these, the country must expect to seed lavishly and to fertilize generously the soil from which they spring. Germany has learned the lesson well: other nations cannot long delay."

Agriculture

In the vast range of the applications of science to agriculture, the same general statements hold good. There is, however, no such general appreciation of the value of training as appears in relation to the various branches of training, and the men of scientific education are mostly absorbed in the many ramifications of the Department of Agriculture and in the state agricultural colleges and experiment stations. There are few illustrations of the power of national coöperation more striking than those shown in the achievements of the Department of Agriculture. I have no time to touch on the varied branches of agricultural research, the study of the chemistry of foods and soils, the practice of irrigation, the fight against adulterations, the fight against noxious insects, and all the other channels of agricultural art and practice. I can only commend the skill and the zeal with which all these lines of effort have been followed.

The art of agriculture is the application of all the sciences. Yet "agricultural education," writes a correspondent, "has not yet reached the dignity of other forms of technical education."

"The endowment of the science of agricultural research in the United States is greater than in any other country. The chief fault to be found is in striving too rapidly for practical applications and in not giving time enough for the fundamental research on which these applications must rest. The proportion of applied agricultural science in agriculture is too great in this country. While we do not need fewer workers in applied agricultural science, we do need more workers who would devote themselves to fundamental research."

Two branches of applied science not specifically noticed in our scheme of classification seem to me to demand a word of notice. One is selective breeding of plants and animals; the other, the artificial hatching of fishes. By the crossing of animals or plants not closely related, a great range of variety appears in the progeny. Some of these may have one or more of the desirable qualities of either parent. By selection of those possessing such qualities a new race may be formed in a few generations. The practical value of the results of such experiments cannot be over-estimated. Although by no means a modern process, the art of selective breeding is still in its infancy. Its practice promises to take a leading place among the economically valuable applications of science. At the same time, the formation of species of organisms under the hand of man throws constant floods of light on the great questions of heredity, variation, and selection in nature, the problem of the origin of species.

In this connection I may refer to artificial hatching and acclimatization of fishes, the work of the United States Bureau of Fisheries and of the fish commissions of the different states. There are many species of fish, notably those of the salmon family, in which the eggs can be taken and fertilized by artificial processes. These eggs can be hatched in protected waters so that the young will escape many of the vicissitudes of the brook and river, and a thousand young fishes can be sent forth where only a dozen grew before.

Medicine

In the vast field of medicine I can only indicate in a few words certain salient features of medical research, of medical practice, and of medical instruction in America.

In matters of research, the most fruitful line of investigation has been along the line of the mechanism of immunity from contagious diseases. To know the nature of microörganisms and their effect on the tissues is to furnish the means of fighting them. "The first place in experimental medicine to-day," says Dr. W. H. Welch, "is occupied by the problem of immunity." That medicine is becoming a scientific profession and not a trade is the basis of the growing interest of our physicians in scientific problems, and this again leads to increased success in dealing with matters of health and disease. The discovery of the part played by mosquitoes in the dissemination of malaria, yellow fever, dengue, elephantiasis, and other diseases caused by microörganisms marks an epoch in the study of these diseases. The conquest of diphtheria is another of the features of advance in modern medicine, and another is shown in the great development of surgical skill characteristic of American medical science. But the discoveries of the last decades have been rarely startling or epoch-making. They have rather tended to fill the gaps in our knowledge, and there remain many more gaps to fill, before medical practice can reach the highest point of adequacy. The great need of the profession is still in the direction of research, and research of the character which takes the whole life and energy of the ablest men demands money for its maintenance. We need no more medical colleges for the teaching of the elements. We need schools or laboratories of research for the training of the masters.

In the development of medicine there has been a steady movement away from universal systems and *a priori* principles, on the one hand, and, on the other hand, from blind empiricism, with the giving of drugs with sole reference to their apparent results. The applications of sciences — all sciences which deal with life, with force, and with chemical composition — must enter into the basis of medicine. Hence the insistent demand for better preliminary training before entering on the study of medicine. "Only the genius of the first order," says a correspondent, "can get on without proper schooling in his youth. What our medical investigators in this country most need is a thorough grounding in the sciences, especially physics and chemistry."

The instruction in medicine, a few years ago almost a farce in America, has steadily grown more serious. Laboratory work and clinical experience have taken the place of lectures, the courses have been lengthened, higher preparation for entrance has been exacted, though in almost all our schools these requirements are still far too low, and a more active and original type of teacher has been in demand. Even yet, so far as medical instruction is concerned, the hopeful sign is to be found in progress rather than in achievement. A college course, having as its major subjects the sciences fundamental to medicine, is not too much to exact of a student who aspires to be a physician worthy of our times and of the degree of our universities. First-hand knowledge of real things should be the keynote of all scientific instruction. "Far more effort is now made," writes a correspondent, "in both the preparatory and the clinical branches to give the student a first-hand knowledge of his subject. This tendency has still a long way to travel before it is in danger of being overdone. The practical result of this tendency is that the cost of education per student is greatly increased and the profits of purely commercial schools are thereby threatened. This forms, doubtless, the main source of the objection made by the weaker and less worthy schools to better methods of instruction. We need well-endowed schools of medicine that may carry on their work unhampered by the necessities of a commercial venture. Medical schools now exist in great numbers, — many of them cannot keep up with modern requirements, and necessarily their salvation lies in antagonizing everything in the nature of more ample and more expensive training."

Another correspondent writes, emphasizing the value of biologic studies: "The final comprehension of bodily activity in health and disease depends on knowledge of living things from ovum to birth, from birth to maturity, and from maturity to old age and death. Anything less than such fundamental knowledge requires constant guessing to fill up the gaps, and guesses are nearly always wrong."

In many regards, even our best schools of medicine seem to show serious deficiencies. The teaching of anatomy is still one of the most costly, as well as least satisfactory, of our lines of work. A correspondent calls attention to the fact that in making anatomy "practical" in our medical schools, "we expended last year $750,000 in the United States, twice the amount expended in Germany, with as a result neither practical anatomy nor scientific achievement." "Anatomy," he continues, "should be made distinctly a university department, on a basis similar to that of physics and chemistry. Unfortunately, university presidents still stand much in the way of the development of anatomy, for many of them seem to think that almost any one who wears the gown is good enough to become a professor of anatomy. Repeatedly have I witnessed the appointment of a know-nothing when a recognized young man might have been had for half the money." Our forces are dissipated, the fear of things scientific has destroyed even the practical in this noble old mother science which is still giving birth to new sciences and to brilliant discoveries.

Among other matters too much neglected are personal hygiene, a matter to which the physician of the past has been notoriously and joyously indifferent. Especially is this true as regards the hygiene of exercise and the misuse of nerve-affecting drugs.

Public sanitation as well deserves more attention. "The demand for adequately trained officers of public health is not what it should be, and our public service as a whole is far below that of European countries. Both public opinion and university authorities are responsible for this condition."

The hygiene of childhood, in which line great advances are made, is still not adequately represented in most of our medical colleges, and the study of psychiatry and nervous disturbances in general is not sufficiently lifted from the realm of quackery. "Not only," says a correspondent, "should psychiatry be taught in every medical school, but it should be taught from a clinical standpoint. Every city in which there are medical schools should have a psychopathic hospital for the reception of all cases of alleged insanity and for their study, treatment, and cure. Such a hospital should contain, also, a laboratory for the study of normal and of pathological psychology. I am convinced that progress in normal psychology will be made chiefly through the study of abnormal conditions, just as physiology has profited so enormously through the work of the pathologist."

A word should be said for veterinary medicine and its achievements of enormous economic value in the control of the contagious diseases of animals. The recent achievements of vaccination against the Southern cattle fever and against tuberculosis, the eradication of the foot and mouth disease among other matters, have demanded the highest scientific knowledge and the greatest skill in its practical application.

Unfortunately, veterinary science lacks in this country adequate facilities for research and instruction. "Practically," says a correspondent, "the veterinary sciences in the United States are leading a parasitic existence. We are dependent almost wholly upon the results of investigation and teaching of European countries, notably Germany and Denmark. The value of the live-stock industry here is so tremendous that almost every state in the Union should have a well-equipped veterinary school supported by public funds. There is but one veterinary school in the United States that has anything like adequate support." That this is true shows that our farmers and stock-raisers are very far from having an adequate idea of one of the most important of their economic needs.

Economics

We may justify the inclusion of economics among the utilitarian sciences on grounds which would equally include the sciences of ethics and hygiene. It is extremely wise as well as financially profitable to take care of one's health, and still more so to take thought of one's conduct. The science of economics in some degree touches the ethics of nations and the "wealth of nations," a large factor in the happiness of the individuals contained within them, depends on the nation's attitude towards economic truths. Another justification of this inclusion is found in the growing tendency in our country to call on professional economists to direct national operations. On the other hand, our economists themselves are becoming more and more worthy of such trusts. The inductive study of their science brings them into closer contact with men and with enterprises. By this means they become students of administration as well as of economics. They realize the value of individual effort as well as the limitations which bound all sorts of executive work, in a republic. "Only a few years ago," writes a correspondent, "the teachers of economics were far more generally unfavorable critics of government work which interested them. They have become more and more disposed to coöperate at the beginning rather than to condemn at the end. Just as economics has taken a more kindly and hospitable attitude towards politics, so similarly has it towards business, as illustrated in the rapid rise of courses in commerce." The demand for trained economists in public affairs is "compelling the teachers of economics more and more to seek contact with the men who are grappling face to face with economic problems."

The relation of economic theory to administration is a subject on which there is much diversity of opinion. It is claimed by able authority that "economic science, by becoming ultra-theoretical, has come into far closer touch with practical life than it ever attained before. Laws, the statement of which seems like a refinement of theory, determine the kind of legislation required on the most practical of subjects." On another hand, it is claimed by high authority that our country must have its own political economy. "The generalizations arising solely from the uniformity of human nature are so few that they cannot constitute a science. The classical or orthodox political economy of England was conditioned from start to finish by the political problems it had to face. We are only beginning to acquire our national independence."

Still another view is that "all that has been achieved in the field of economics that is of any value, has been the result of logical analysis applied to the phenomena and experiences of every-day industrial life. The stages of past development can be determined and interpreted only in the light of this analysis. The lesson which the historical economist has never learned, is the importance of that principle, which lies at the bottom of the whole modern theory of evolution, and which was made use of by Lyell and Darwin, namely, the principle that historical changes of the past are to be accounted for by the long continued action of causes which are at this present moment in operation and can be observed and measured at the present day." "This," says my correspondent, "needs saying and re-saying, until it is burned into the minds of all students of economics."

The recent progress of economics in America has lain in part in the development of economic theory by critical and by constructive methods. An important reason for welcoming the exact and critical study of economic theory is this: In the promulgation of imaginary economic principles the social and political charlatan finds his choice field of operation, just as the medical charlatan deals with some universal law of disease and its universal cure. The progress of science in every field discredits these universal principles with their mystical panaceas. There is all the more reason why in politics, as in medicine, those generalizations which deal with necessary laws or actually observed sequence of events should be critically and constructively studied.

In general, however, the progress of economics has followed the same lines as progress in other sciences, through a "minute investigation and the application of principles already discovered or outlined by painstaking inquiry as to facts." This method of work has been especially fruitful in the study of monetary problems, of finance, taxation, and insurance, in the study of labor problems and conditions, in the study of commerce, and in the study of crime and pauperism. In its development economics is, however, many years behind the natural sciences, a condition due to reliance on metaphysical methods and to the inherent difficulty in the use of any other.

"Economics," says a correspondent, "has been less successful than the material sciences in getting rid of the apparatus of metaphysical presumptions. The economist is still too eager to formulate laws that shall disclose the ultimate spiritual meaning of things instead of trying to explain how these things came to pass. He has profited in small degree by those lessons which the progressive evolutionary sciences have driven home in the past in the methods of thinking of workers in other fields. Our science is still sadly behind the times in its way of handling its subject-matter. The greatest and most important work of economic investigations is to make students see things as they are, to fit young men for the more highly organized business new conditions are ushering in, and give a better appreciation of the problems of government and a better training for participation in them."

Says another correspondent: "Training in research is in fact essential to every technical man. The young technologist will be confronted by new problems not covered by anything in literature or in his past experience. Training in research is training in the art of solving unsolved problems, and the practical man who has had discipline of that kind has a great advantage over his more conventional competitors. The Germans recognize this principle, and behold their marvelous industrial growth. The student in every department of science should be taught to think as well as to do."

The time must come when a man who has no training and no experience in research will not be called educated, whatever may be the range of his erudition. To unfold the secret of power is the true purpose of education.

DR. DEAN OPERATING BEFORE HIS CLASS

Hand-painted Photogravure from the Painting by H. Gervex

The fascinating gruesomeness of a serious surgical operation incorporated, so to speak, with the scientific aspect, is the subject of Gervex's ambitious effort, shown at the Paris Exposition, 1889. The operator is Dr. Jules Dean, author of several works on Surgery, Officer of the Legion and Member of the Institute, France. The painting represents a handsome young girl prepared to undergo an operation for an affection of the throat. Dr. Dean is explaining the case to his class before using the knife, and the countenances of his auditors indicate the gravity of his words, a treatment that evidences the genius of the artist.

DEPARTMENT XVII — MEDICINE

DEPARTMENT XVII — MEDICINE

(*Hall* 1, *September* 20, 4.15 *p. m.*)

CHAIRMAN: DR. WILLIAM OSLER, Johns Hopkins University.
SPEAKERS: DR. WILLIAM T. COUNCILMAN, Harvard University.
DR. FRANK BILLINGS, University of Chicago.

THE MODERN CONCEPTIONS AND METHODS OF MEDICAL SCIENCE

BY WILLIAM THOMAS COUNCILMAN

[**William Thomas Councilman**, Shattuck Professor of Pathological Anatomy, Harvard University Medical School. **b.** Maryland, 1854. M.D. Maryland University; A.M. (Hon.) Harvard and Johns Hopkins University. Graduate student of Johns Hopkins University; special course, Vienna, Leipzig, Prague, Strassburg. Assistant in Physiology and Anatomy, Associate Professor, Johns Hopkins University. Member of Association of American Physicians, National Academy of Science. **Author of** medical works on *Diphtheria; Small-Pox;* and *Cerebro-Spinal Meningitis*.]

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 ontologic 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 action exerted leads to forms of activity which differ from and fail to come into accord with the usual activities, whatever produces such an action is a cause of disease. These 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 conditions 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 thrust 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 philosophic 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 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 rôle in systems of religions, and the teachers of the system who had most fully embraced its tenets were supposed to be the most efficacious in removing disease. 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 important 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 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 of 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. He 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 unfailing 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 1300 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 were 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 the Renaissance passed with little or no influence on medicine, for mental activity was turned exclusively 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 more 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 precept of Bacon, that knowledge increases by the observations 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 in Europe its ascendency. 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 equaled by few. Haller recognized the important fact that life was a property inherent in the tissues and manifested 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 believed 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. 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 philosophic 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 meager 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 *Archivs*. 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 the influence which he exerted. He substituted for the ontologic 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 proved 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 ontologic 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 anatomic 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 anatomic 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-Sequard, who further developed his methods. Corvisart, Andral, Louis, Rayer, and Cruvilhier 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 method 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 an 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 carmin stain of Gerlach. In clinical medicine the introduction of the microscope, the thermometer, the methods of chemic investigation, the blood-counter, the Röntgen 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 toward 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 ascendency, 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 anatomic 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 demonstration of anesthesia came first from the surgeon, 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 of 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 excretion, 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 knowedge 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 only read 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 separation 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 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 and 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 mostof 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 that 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 organisms 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 of, 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 susceptibility 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 chemic 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 chemic 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 upon 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 consequences. 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 coöperation 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 objective 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 is directly dependent upon the habit of investigation. 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.

THE DEVELOPMENT OF MODERN MEDICINE

BY FRANK BILLINGS

[**Frank Billings,** Professor of Medicine, University of Chicago, and Professor of Medicine and Dean of Faculty, Rush Medical College. **b.** April 2, 1854, Highland, Wisconsin. M.D. Northwestern University Medical School, 1881; M.S. *ibid.* 1890; Demonstrator of Anatomy, *ibid.* 1882-85; Lecturer on Physical Diagnosis, *ibid.* 1883–87; Professor of Physical Diagnosis, *ibid.* 1887–91; Professor of Medicine, *ibid.* 1891–98; Professor of Medicine, Rush Medical College, 1898; Dean of Faculty, *ibid.* 1900. Member of Association of American Physicians; Association of American Pathologists; American Medical Association; Illinois State Medical Society; Chicago Medical Society; Chicago Pathological Society; Chicago Academy of Science; Chicago Neurological Society; Chicago Literary Club. **Editor of** *Year-Book of Medicine.*]

Modern medicine is a composite of the knowledge of many sciences. The last twenty-five years mark the period of the greatest evolution of medicine in its history. The foundation of modern medicine was laid by the labors of hundreds of earnest workers in the field of science during the last three centuries. As a rule the value to modern medicine of these pioneer investigators was in an inverse ratio to the length of the period which separated them from modern times. Exceptions to this rule are found, however, even in the seventeenth and eighteenth centuries. Indeed, at that period when one considers the superstition, prejudice, mystic belief, magic, astrology, dogma after dogma, and system after system which prevailed, the inheritance of the dark ages, our admiration is excited by the really great results of the work of some of the scientists. Until the seventeenth century, Hippocrates, Galen, and Aristotle were the authorities in medicine. There was practically no advancement in medicine in that period of time. Anatomy and pathology were not understood; dissection was forbidden by the clergy of the Middle Ages, because it was considered impious to mutilate a form made in the image of God. Dissections of the human body were practiced to a limited degree during the fourteenth and fifteenth centuries, but the sixteenth century was marked by the birth of Vesalius, a naturalist, whose investigations in human anatomy marked the beginning of scientific medicine.

The seventeenth century marked the birth of realism. Galileo was a reformer in physics, and other scientific men broke away from the superstitions and dogmas of the day and searched for light along self-chosen paths. During the century, Harvey discovered the circulation of the blood. Zoölogy and botany were cultivated. Romer calculated the velocity of light. Lord Bacon's brilliant mind shone resplendent. Sir Isaac Newton discovered the law of gravity. Malpighi, Steno, Bartholin, De Graf, Wharton, Nuck, Brunner, Wirsung, Peyer, Havers, Cowper, Schneider, Hewson, Vieussens, and Merkel, and many others, dissected out everlasting monuments of their genius and skill. Hooke introduced the term "cell," and the cell-doctrine was founded by Malpighi and Grew. Linnaeus, Kant, Richelieu, Mazarin, Molière, Bach, Hayden, Beethoven, and Goethe were contemporaries of these other great men. Peruvian bark was introduced into Spain during this period.

The eighteenth century, called the golden age of medicine, witnessed a continuation of the constructive and realistic work of the previous century. Pathologic anatomy was born, and in the person of Morgagni received an impetus which gave it everlasting life. John Hunter, Baillie and Home in England, and Bichat in France were worthy successors of Morgagni. In this century Leopold Avenbrugger, the discoverer of percussion as a means of diagnosis of the diseases of large organs of the body, introduced the method in clinical investigation. Haller originated experimental physiology. An ambulatory clinic was inaugurated at Prague in 1745, and the first clinical institute was founded at Vienna in 1754 by Van Swieten. Preventive inoculation against small-pox was performed, a method of protection against variola which was practiced by the Chinese a thousand years before Christ. The most notable event of that period occurred at the close of the century with the discovery, by Edward Jenner, of vaccination as a protection against small-pox.

The period marked by the first seventy-five years of the nineteenth century was but a continuation of the tendencies of the preceding period. The watchword of medicine was pathological anatomy and diagnosis — the so-called scientific or exact medicine. This tendency to realism was modified to some degree by the philosophic teaching of Schelling, Hartman, Spencer, Haeckel, Hagel, and others. Pathologic anatomy found brilliant exponents in Bretonneau, Corvisart, Bright, Rokitansky, Louis Magendie, and many others. The practical salutary effect of pathology upon practical medicine was evinced by the epoch-making clinical observations of Addison, Graves, Cheyne, William Stokes, Trousseau, Wunderlich, Ziemmsen, Corrigan, and others. Notable was the advancement made in physical exploration in diagnosis. Avenbrugger's invention of percussion was extended by the translation of his book and the adoption and improvement of the method of percussion by Corvisart.

In 1815, Laennec invented the stethoscope. Skoda developed both percussion and auscultation and published his famous work on these subjects in 1839. Thus in medicine we find that, even in that early day, the pathologist and the clinician taught that by the aid of its special senses and by the microscope and instruments of precision the diagnosis could be made with a definiteness, impossible by the use of the symptoms alone.

The epoch-making work of Johannes Mueller in embryology and physiology marked the beginning of modern physiology, and this, with the unparalelled activity of Virchow in pathology, resulted in an enormous development of scientific observation and productiveness.

Corresponding activity marked the work in the sciences of chemistry, zoölogy, comparative and human anatomy, physics, botany, and general biology. The development of the microscope gave impetus to the study of the lower forms of life. In 1838, Ehrenberg regarded infusoria as animals. In 1852, Perty claimed that most infusoria should be assigned to the vegetable world. Cohn proved the correctness of this conclusion and perfected a classification. In 1837, Bassi discovered the parasitic nature of silk-worm disease. The parasitic form of favus and thrush was proved by Schoenlein and Nagel respectively. Dovaine recognized the anthrax bacillus in 1850. In 1857, Pasteur demonstrated that fermentation and putrefaction were caused by lower organisms and at the same time forever set at rest the superstition of spontaneous generation. Obermayer recognized the spirillum of relapsing fever in 1873. Bacteriology became an exact science with the discovery by Robert Koch of cultural methods which made the differentiation of germs possible.

The causative relations of bacteria and microörganisms to all infective processes has been proved by the laws promulgated by Koch. The discovery by Brieger, Panum and others of the poisons produced by bacteria was another important step in the progress of bacteriology as related to medicine.

From the discovery and development of bacteriology, and especially through the brilliant researches of Pasteur and Koch and of their students, has resulted a knowledge which has revolutionized and marked the birth of modern medicine.

Parasites

The discovery of the hematozoön of malaria by Laveran; the recognition of the ameba of dysentery by Loesch; of the ray fungi and especially the actinomyces as infective agents in the lower animals and in man and the more exact knowledge of other animal parasites infecting man and animals, which the microscope has made clear, have been as epoch-making in parasitology as the discoveries of Pasteur and Koch in bacteriology.

The recognition of the relation of bacteria, protozoa, and animal parasites to infective disease has been the means of a more exact knowledge of the clinical phenomena of disease, of morbid anatomy, of physiology, and of physiologic chemistry than would have been possible without it.

Transmission of Infection

The knowledge of the cause of disease has led to a study of the life-history of infective organisms outside of as well as in the animal body. The mode of propagation, the means of transmission of infective microörganism, by fomites and other agents, has become known. The rôle of insects which infect animals play, as definitive or intermediate hosts, has been studied and proved. The discovery of Manson of the transmission of Filaria sanguinis hominis by the mosquito was of vast importance as a suggestion of the mosquito as a definitive host in malaria. The investigations of Manson, Ross, Celli, Grassi, Dionise, Marchiafava, Bignami, Koch, and others have made our knowledge of malaria exact. With the microscope we may now not only recognize malaria and differentiate it from the other infective fevers, but we may also at the same time recognize by an examination of the blood the type of malarial infection and foretell its course. Not only may we recognize the disease definitely and apply the drug treatment more rationally, but the knowledge of the means of its transmission from man to man enables us to apply preventive measures which are of the greatest importance from a commercial as well as from a humanitarian point of view. The recognition of the rôle of the mosquito in malaria has been, furthermore, a stimulus to the study of the same insect in relation to other infections.

The brilliant research work of Reed and Carroll in 1900 in Cuba, by which they proved that the mosquito of the genus stegomya is the sole means of the transmission of yellow fever from man to man, is of great importance as a scientific fact. The influence of this discovery upon mankind, as a prophylactic against a disease which has killed multitudes, is wonderful.

Hardly less important is the fact that the Bacillus pestis may infect fleas and these in turn infect rats, mice, and man. It is important, too, to know that pests like the house-fly may be carriers of infective bacteria from refuse filth to kitchens and tables and contaminate food, and thus infect u swith typhoid fever, cholera, and perhaps other diseases which are propagated by filth.

The study of bacteria in the laboratory and in the blood tissues of infected animals has led to the discovery of the means by which bacteria disturb the animal economy and produce phenomena expressive of disease. The fact that the blood and tissues of infected animals contained a toxin which could also be isolated from pure bacterial cultures in the laboratory and that this toxin when introduced into an animal was capable of exciting the same phenomena of disease as the bacteria themselves, was positive proof that bacteria excite disease phenomena at least in some instances by means of a toxin which they form. The elaboration of antitoxins in the body of the infected animal was also promptly recognized, and served to explain not only the self-limitation of many of the infective diseases, but it also helped us to understand the immunity which one attack affords in some of the bacterial diseases.

Protective Inoculation

Long before bacterial toxins were recognized as the cause of disease phenomena, Pasteur established the principle of protective inoculation with bacteria of lessened virulence, which was brought about by attenuation of the bacteria by a modification of cultural methods and also by serial inoculation of certain lower animals. This he successfully applied to charbon in sheep and cattle and to chicken cholera. In both of these diseases the bacteria were known and the problems of attenuation could be carried on in the laboratory by direct study of the bacteria before inoculation and afterward when they were recovered from the body of the animals experimented upon.

His final life-work was no less important in firmly fixing the immunizing influence in rabies. Here the discovery was made that the infecting bacterium escaped every known means of recognition by microscopical and cultural examination of the tissues and blood of the infected animals. Apparently there are pathogenic germs which we do not know because we have not yet recognized the proper culture material for the successful artificial cultivation of them, nor have we discovered the tinctorial reaction which they may possess; and, finally, it is not improbable that they may be infinitely smaller than other germs and, therefore, more difficult to recognize.

Pasteur recognized the fact that in hydrophobia the brain and other nervous tissues of an infected animal are capable, when inoculated into another animal's brain, of producing the disease. That the infected brain used for infecting animals contained the germs which caused the disease was proved by the fact that a stage of incubation occurred in the inoculated animal and that a series of animals were successfully inoculated consecutively from the first. Pasteur then successfully attenuated the unknown microorganism present in the nervous tissues of an inoculated animal by dessication of the nervous tissue in a sterile apparatus by methods too well known to repeat. Nor is it necessary to occupy time in repeating the well-known methods pursued by Pasteur and his pupils in the use of the graduated doses of attenuated toxin contained in the nerve tissues in the prophylactic treatment of rabies. To Pasteur, therefore, we owe the scientific recognition of the principle of protective inoculation.

It is now a well-known fact, however, that inoculation against disease was practiced by the Chinese a thousand years ago. They inoculated the healthy with small-pox as a protection against the disease. Variolization was also practiced in Europe in the seventeenth and eighteenth centuries. We read that in 1718, Lady Montague caused a son to be inoculated with variola in Italy, and that two years later her daughter was inoculated in England. The practice was followed in Ireland long after the successful establishment of vaccine as a protection against variola. Inoculation against syphilis, or syphilization, was practiced in Europe during the nineteenth century.

We owe to Jenner, however, the first example of the protective inoculation by means of an attenuated virus. This attenuation we now know was established by the accidental inoculation of milch cows with small-pox, producing a modified disease, vaccinia. That vaccinia, produced in man by inoculation, would protect against small-pox was proved when, in 1798, Jenner successfully vaccinated direct from the cow, the five-year-old lad William Summers.

The thousands of successful vaccinations which have since been performed and the thousands of lives which have been saved by vaccination are proof of its validity and utility. The immunity established by protective inoculation is apparently the same as that induced by an unmodified attack of variola.

Serum Therapy

When chemistry had revealed the nature of bacterial poisons and experiments established their relation to the phenomena of disease, it was proved that substances were formed in artificial culture media and in the blood and tissues of infected animals which had the power to neutralize the effect of the bacterial poison in other animals infected with the same organism. Further investigation showed that an animal inoculated with the laboratory preparation of antitoxin was protected against the disease.

Furthermore, it was found that the blood serum of an animal inoculated with bacteria in a non-fatal and repeated dose contained an antitoxin. When the blood serum of an infected animal was injected into a healthy animal, the latter was protected against the original disease.

Antitoxin was, therefore, proved to be formed in artificial media of bacterial cultures and in the bodies of infected animals. When the antitoxin thus formed was injected into an animal, it had the power to protect that animal against the particular bacterial infection, or, if given subsequent to the infection of the animal, to mitigate the severity of the disease or entirely to check it.

Thus Koch and his students established the principle of serum therapy. Upon this principle there has been developed and given to the world the anti-diphtheritic serum of Behring and of Roux, and also an immunizing serum for Asiatic cholera, tetanus, erysipelas, plague, epidemic dysentery, streptococcus infection, and other diseases. While the serum treatment has not proved successful in all of the diseases in which it has been used, it has been so successful in some — diphtheria, for instance — as firmly to establish the principle of serum therapy. The study of prophylactic sera by Paul Erlich led to our present knowledge of immunity. His side chain theory has established a working basis which affords superb fields of research in physiologic chemistry which have already yielded rich returns.

Bacteriology made possible the comprehension of perfect cleanliness and enables the surgeon to invade every part of the body without fear of infection and has saved thousands of lives which twenty-five years ago would have perished miserably as the result of disease at that time inoperable, or as the result of infection from contact with the surgeon. By means of cleanliness and skill, induced by a broader experience, the surgeon has been able to add to our knowledge information of great value which could have been obtained probably in no other way. He has been able to study disease in the living body and show the relation of a disease process to infection. He has thus been able to clear away many of the misconceptions of symptomatology and diagnosis, especially in disease of the abdominal organs.

Bacteriology has stimulated laboratory clinical diagnosis. Bacterial reaction to sera and blood cultural tests are of the greatest aid to diagnosis. Clinical research work has command of an armamentarium consisting of a knowledge of pathologic anatomy, of physiology, of bacteriology, of chemic physiology, and of physics, which allows of a precision in diagnosis never before at the command of the physician.

The evolution of bacteriology has afforded a stimulus and aid in the advancement of parasitology, physiology, physio-chemistry, and of other fundamental sciences. This knowledge has been more directly applied to practical medicine than ever before.

Indeed modern medicine is now so comprehensive that the student must be thoroughly conversant with chemistry, inorganic, organic, and physical, with physiology, with general biology, with human and comparative anatomy, with bacteriology, and parasitology, to understand and appreciate it.

Slowly but surely the secrets of the cause of disease which baffled the search of centuries have yielded to the brilliant light of modern methods. The causative agents of most of the infective diseases of man and of the lower animals are now known.

The unknown causative germs of the few remaining infectious diseases will soon be discovered, and then the principles of immunity and cure by inoculation or by the application of antitoxins will find wider application.

Prevention of Infection

The recognition of the germ-cause of the infectious diseases enables modern medicine not only to combat disease more rationally and successfully, but it enables us to prevent them.

In most of the infective diseases due to germs, protozoa, parasites, and fungi, the causative agents have been so fully investigated that we know the life-history, and what conditions are best suited for the propagation and multiplication of each, and also what will remove and annihilate these dangerous enemies. So the diseases of domestic animals which may also infest man, for example, actinomycosis of cattle, trichina of swine, tuberculosis of animals, chicken cholera, foot and mouth disease, charbon, etc., may be entirely eradicated. The experience of one hundred years proves that smallpox may be prevented by proper vaccination. If universally applied and repeated at proper intervals the disease would probably disappear.

Our knowledge of the living agents which provoke malaria, typhoid fever, cholera, the plague, and the means by which they propagate, develop, and the manner in which they infest man, enables us, if we may command the situation irrespective of the financial cost, not only to prevent but also in many localities to abolish them altogether.

The discoveries of Reed, Carroll, and Agramonti of the relation of the mosquito (Stegomyia fasciata) to yellow fever has been practically applied with notable success in Cuba and elsewhere.

The study of bacteriology has developed general hygiene to a high plane. The value of sunlight, pure air, and pure food are fully recognized as preventives and also as rational curative measures in many infective diseases.

Unfortunately there are a few of the scourges of mankind which science has not yet conquered. Pneumonia, the bacterial cause of which is known, is still a "captain of death." Cancer remains unconquered. So, too, do many of the chronic diseases, namely, the primary blood diseases, diabetes, the various degenerative processes, etc., which, though frequently easily recognized during life, are at best only modified by our efforts to check or remove them.

Physio-chemistry, experimental medicine, physiology, and pathologic anatomy have given us much information of these processes, and there can be no question that many of these problems will be solved by the present methods of investigation.

The present knowledge of the cause of disease, of the evolution of disease processes, of the natural expression of disease as recognized by clinical investigation, has resulted in a rational mode of treatment. Drug treatment is no longer looked upon as specific, but as a helpful agent to modify and palliate disease processes, in conjunction with proper dietary, hydratic, and hygienic measures. Polypharmacy and indiscriminate drugging and drug nihilism are recognized as equally irrational. It requires a nice judgment of when to give, as much as when to withhold, drugs.

To enable a diseased or crippled organ more nearly to perform its function; to fortify and prolong life, with the hope of a favorable termination of a self-limited disease; to palliate suffering, are some of the measures which drugs afford modern medicine. Pharmacology and pharmacy have developed equally with the other parts of medicine and enable us to command drugs and active principles with accuracy and comfort.

The discovery of the X-ray was a boon tosurgical diagnosis and it has proved of wonderful therapeutic value in many of the disease processes of the skin and superficial tissues. When the X-ray shall be better understood its appreciation will be undoubtedly much more extensive.

The rapid development of modern medicine has attracted wide attention and excited the interest of students and investigators over the whole world.

A larger percentage than ever before of the best-educated students of the world have sought medicine as the most attractive field of study and research. At this time there are hundreds of earnest, thoughtful, patient, and energetic workers after truth who frequently sacrifice home, friends, comfort, health, and even life for the advancement of the science of medicine.

The advancement of modern medicine has also attracted the attention of the philanthropic rich as never before. In recent years institutes of research have been erected or are in the course of construction and equipment which have rich endowment. Modern medicine is therefore better prepared to develop now than ever before.

The development of medical literature has been in keeping with the advancement of other sciences. Large and valuable libraries are found in every land. Medical journalism is a science of itself and enables the physician at small cost to be in touch with all that is new and progressive.

Modern medicine requires of its students an education which shall fit them to take part as research workers or as practitioners to apply the measures afforded them to prevent or more quickly to modify disease. The modern medical student, therefore, requires the broad education of the university and a training of his special senses in the study of the natural and of the fundamental medical sciences, preliminary to the study of applied medicine and surgery. Happily both the old and the new world afford institutions which satisfy all requirements of modern medical education. Many medical institutions exist which cannot furnish the necessary educational advantages. These institutions are doomed. They are relics of the past. It is to be hoped that they will be no exception to the rule of the survival of the fittest.

SECTION A — PUBLIC HEALTH

SECTION A — PUBLIC HEALTH

(*Hall* 13, *September* 21, 10 *a. m.*)

CHAIRMAN: DR. WALTER WYMAN, Surgeon-General of the U. S. Public Health and Marine Hospital Service.
SPEAKERS: PROFESSOR WILLIAM T. SEDGWICK, Massachusetts Institute of Technology.
DR. ERNST J. LEDERLE, Former Commissioner of Health, New York City.
SECRETARY: DR. H. M. BRACKEN, St. Paul, Minn.

DR. WALTER WYMAN, Surgeon-General of the United States Public Health and Marine Hospital Service, and Chairman of the Section of Public Health, in calling the Section to order, expressed his appreciation of the honor that had been conferred upon him in being made the presiding officer of so important a section, and congratulated the members of the Congress who were present on taking part in a congress so unique in history, so distinguished in membership, and whose proceedings would doubtless prove of such great value to mankind.

Recent legislation (Act of July 1, 1902) had provided for the United States a body practically fulfilling the requirements of a national board of health under the name of Public Health and Marine Hospital Service, an evolution from the century-old Marine Hospital Service. The Service controlled a laboratory for the investigation of infectious diseases and matters relating to the public health, its medical corps comprised between three hundred and four hundred medical officers, distributed throughout the United States and also representing the Service in foreign lands in sanitary matters.

The difficulty had been hitherto to establish a national health organization in which there might be a representation of the states without weakening the administrative and executive force of the national service and giving the states a voice in at least the consideration of matters pertaining to the public health. This had been brought about by the provision for annual conferences between the state and national health authorities.

One difficulty which has always faced Congress in the establishment of a national health organization was not to assume extra, constitutional rights. The power of Congress in matters pertaining to epidemic disease and matters relating to public health lie chiefly in its power to regulate commerce, though doubtless many would believe that under the public welfare clause of the Constitution certain beneficent institutions could be organized and maintained by the national government. As a matter of policy, the attitude of Congress is also in accord with the spirit of the Constitution. It has not been deemed desirable that the United States Government should be too paternal, but should leave most of the details in public health matters to the state and municipal governments. Occasionally there is a tendency toward a weak leaning on the national government, which should not be encouraged, but in the opinion of the Chairman it is the wisest policy at present that the national government should only give aid when it is necessary to do so in the interest of several states or communities combined. The leaving of ordinary public health matters to the management of the state health boards would strengthen them in their organization and in their appeals to the state legislatures for appropriations. Any national system must necessarily include, for its efficacy, the health organizations of the several states and their development in power.

Time may develop a closer relation between the national and state, or local, governments with regard to local sanitation, since the latter is closely connected with epidemic diseases which become the care of the national authorities.

Through the Hygienic Laboratory, with its advisory board, the scientific work of the Public Health and Marine Hospital Service is brought into contact with the scientific laboratories of the country. Through the conferences with the state health officials the practical administrative work of the Bureau and its various sanitary problems are now considered in conjunction with the official representatives of the state governments; and a good scientific and executive framework of the national health structure exists in the corps of specially trained medical officers, under military discipline, and trained in government methods.

The national health organization, as thus outlined to-day, is much stronger than was the old national board of health, but it should be stated that while the organization seems to have sufficient scope, much remains to be done to perfect the details.

THE RELATIONS OF PUBLIC HEALTH SCIENCE TO OTHER SCIENCES

BY WILLIAM THOMPSON SEDGWICK

[**William Thompson Sedgwick,** Professor of Biology, Massachusetts Institute of Technology. **b.** West Hartford, Connecticut, December 29, 1855. Ph.B. Sheffield Scientific School, 1877; Ph.D. Johns Hopkins University, 1881; Fellow, *ibid.* 1879–80. Instructor in Physiological Chemistry, Sheffield Scientific School, 1878–79; Instructor and Associate in Biology, Johns Hopkins, 1880–83; Assistant Professor, Associate Professor, and Professor in Biology, Massachusetts Institute of Technology, 1883; Biologist of Massachusetts State Board of Health, 1888–96; Curator of Lowell Institute, Boston, 1879. Member of American Association for the Advancement of Science, Society of American Bacteriologists, American Public Health Associations, American Society of Naturalists, American Academy of Arts and Sciences. Author of *General Biology* (joint author); *Life and Letters of William Barton Rogers* (assistant editor); *Principles of Sanitary Science and Public Health; The Human Mechanism* (joint author).]

"Physical science is one and indivisible. Although for practical purposes, it is convenient to mark it out into the primary regions of physics, chemistry, and biology, and to subdivide these into subordinate provinces, yet the method of investigation and the ultimate object of the physical inquirer are everywhere the same." — Huxley.

Physical Science is one and indivisible; that, as I understand it, is the keynote of this great Congress, of which public health science forms one section, and as I am invited to consider, in the brief space of forty-five minutes, the relations of public health science to other sciences, I shall take the liberty of selecting from the whole number of "other sciences" only a few, the relations of which to public health science seem to me for one reason or another especially important at the present time. I accept the term public health science without hesitation, for any division of human knowledge which has worked out its own laws with strict adherence to the rules of inductive and deductive reasoning, as public health science has done, and which has reached results enabling it to predict with accuracy, as public health science can now predict, is entitled to a place and an honorable place among the physical sciences.

Public health science had its rise and a considerable development in the eighteenth century. Before that time numerous procedures tending to protect or promote the public health had, indeed, at one time or another existed, but these were largely empirical and quite as often directed to the convenience of mankind as to their sanitary safety. In this class belong the Mosaic code; the water-supply introduced into Jerusalem by Hezekiah; the sanitary engineering of Empedocles; the *Cloaca Maxima;* the water-supplies of ancient Mycenae and of Rome, and all the earlier, and too often futile, forms of quarantine. Even the art of inoculation for small-pox was only an ingenious knack introduced from the East, where it had been long used empirically, and although it was a public health measure now of the utmost interest and capable at the time of great practical service, it had until recently no scientific basis, but belonged in nearly the same class as the amulets and charms, the prayers and incantations, of the superstitious.

It was not until the middle of the eighteenth century, namely, in 1767, that Sir George Baker, by the use of the methods of pure inductive reasoning, made the first scientific discovery in public health science in the subdivision of epidemiology, namely, that the epidemic cholic of Devonshire, England, was due to an obscure poisoning by lead conveyed through the common cider used for drinking in that district. In 1774, the foundations of state hygiene and sanitation were laid in consequence of the patient investigations and startling revelations of John Howard, by an act of Parliament providing for the sanitation of jails and prisons. The beginnings of marine hygiene and sanitation appear in 1776, when Captain Cook, the navigator, was awarded the Copley Medal of the Royal Society for his remarkable success in protecting the lives of his sailors on his second voyage. In 1796, Edward Jenner, working also in a strictly scientific manner, and employing the methods of rigid inductive research, laid securely for all time the foundations of personal hygiene and immunization, by showing how we can produce at will such modifications of the physiological resistance or susceptibility of the human body as to make it immune to small-pox.

The importance of these fundamental and splendid discoveries, not only to the public health of the time, but far more to the development of public health science in all the centuries to come, is incalculable. Reduced to their lowest terms, we have in these eighteenth century discoveries the germs of some of the most important divisions of public health science as it is to-day, namely, (1) *epidemiology*, (2) *sanitation of the environment*, and (3) *immunization of the human mechanism*, this last the most marvelous phenomenon hitherto discovered in personal hygiene.

Time fails me to do more than name some of the principal steps in the advancement of public health science in the nineteenth century. We have, for example, in 1802, the beginnings of factory hygiene and sanitation; in 1829, the first municipal water-filter, one acre in area, constructed for the Chelsea Company of London; in 1834, recognition of the important relation of poverty to public health, in the famous report of the Poor Law Commissioners of that year; in 1839, the beginnings of registration and accurate vital statistics; in 1842, an important report on the sanitary condition of the laboring population of England; and in 1843, a similar report on the health of towns; in 1854, for the first time clearly taught, the lesson, even yet not properly taken to heart, that drinking-water may be the ready vehicle of a terrible epidemic of cholera. About 1860, striking epidemics of trichinosis first came into public notice, and here, also, belongs the magnificent work of Pasteur, while in 1868, Lister, following in the footsteps of Pasteur, revealed to the world the basis of true cleanliness in asepsis, and in 1876, bacteriology became firmly established as a science by Koch's studies on anthrax. The decade from 1880 to 1890 may be called the golden age of etiology, for in these years were discovered the hitherto unknown parasitic microbes of typhoid fever, tuberculosis, malaria, Asiatic cholera, diphtheria, and tetanus. The last decade of a century which has well been called "the wonderful," witnessed the discovery of antitoxins by Behring and the beginnings of serum therapy. The list is long, and I have not mentioned nearly all of the discoveries of capital importance, but because of these and their fruits, I am in the habit of saying to my students that with the single exception of the changes effected by the acceptance of the theory of organic evolution, there has been no modification of human opinion within the nineteenth century more wonderful, or more profoundly affecting the general conduct of human life, than that in our attitude toward the nature, the causation, and the prevention of disease — that is to say, toward public health science.

No mere outline like this of the history of public health science can possibly serve to show how, like other applied sciences, this one has not grown as a branch grows from a tree, namely, from a large stem or stock of knowledge, tapering out into thin air, and with its latest growth its least and weakest. That common simile, in which the various divisions of science are represented as branches of the tree of knowledge, is a grotesque survival of a time when neither trees nor science were understood. No simile is perfect or even approximately correct, but one better than the tree and its branches for the origin and relationships of any inductive science is that of a river, rising from various and often obscure sources, growing in size and importance as it proceeds both from the springs within its own bed and by the entrance and contributions of tributary streams, and finally pouring its substance into the mighty ocean of accumulated human knowledge.

Up to the time of the establishment of the registration of vital statistics in England, in 1839, the stream of public health science, although full of promise, was only a slender thread, but when the results of registration were fully enlisted in its service it visibly widened and deepened. Epidemiology, as has been said, had the honor of giving birth to the science in 1767, and it added to its offspring a rich endowment when, in 1854, Dr. John Snow proved that the water of the Broad Street well in London had caused an epidemic in which more than six hundred persons died of Asiatic cholera. The stream of public health science was still further enlarged and quickened by the revelation in and after the sixties of the simple causes of numerous epidemics of trichinosis and of typhoid fever, the latter sometimes through milk. There was an extraordinary popular awakening in England to the importance of sanitation and public health measures in the middle of the nineteenth century, but we look for some time in vain for any marked inosculation between public health science and other sciences, such as physics, chemistry, microscopy, bacteriology, climatology, engineering, or education. We have, to be sure, minor contributions from the microscopists, such, for example, as that from Dr. Hassall, who, in 1850, made a careful microscopical examination of the water-supply of London and showed the presence in the public drinking-water of muscle fibers, intestinal parasites, and other materials, plainly derived from sewage; but it was not until Pettenkofer and his disciples, in Germany, and Angus Smith and others, in England, began their splendid chemical investigation that the tributary stream of *sanitary chemistry* enlarged materially that of public health science. In saying this I do not forget that my late friend and colleague, William Ripley Nichols, whose solid contributions to sanitary chemistry were among the first in America, and will always remain among the best anywhere, long ago pointed out that, as early as 1789, "Fourcroy studied the nature of 'litharged' wine, Berthollet (1801) the methods of preserving water for long voyages, Chevreul (1846) various chemical reactions which explain the hygiene of populous cities, and (1856, 1862, 1870) methods of preparing and preserving food; Graham and Hofmann reported upon the use of acetate of lead in sugar-refining (1850), upon the London water-supply (1851), and upon the adulteration of pale ales with strychnine (1882); Dumas was interested in many sanitary matters and made, among others, reports on the mineral waters of France (1851), on the water-supply of Paris (1859), on the treatment of sewage (1867), and on the preservation of food (1870–72); Wurtz was for a number of years president of the *Comité consultatif d'hygiène* and a year before his death was president of the *Société de médecine publique*. His investigations and reports on sanitary subjects are numerous — on the disposal of the waste from distilleries and sugar-refineries, on the colors employed on German toys and in articles of food, on the adulteration of wines, etc.

"Other names will occur to us — such as those of Sir Henry Roscoe, Sir Frederick Abel, and Dr. Williamson, who served on the Noxious Vapors Commission of 1876; of Frankland, who gave years of service to the Rivers Pollution Commission of 1868 and in connection therewith devised an elaborate system of water analysis; we think also of Schutzenberger devising a method for the determination of oxygen dissolved in water (not, to be sure, simply for sanitary purposes), Mallet studying the various methods of water analysis, Remsen studying the organic matter in the air, and Leeds the practical effect of charging with oxygen (or rather with air) water used for purposes of domestic supply." [1]

I dwell intentionally upon the service of sanitary chemistry to public health science previous to the rise of bacteriology, because I believe that, dazzled as we have been and still are by the blazing achievements of bacteriology, beginning, let us say, with the discovery of the microbe of tuberculosis by Koch in 1882, students of public health science have been too much inclined to underrate the past services and present relative importance of sanitary chemistry. I know of few more important contributions to public health science, even since 1882, than the chemical work of the State Board of Health of Massachusetts under the able direction of my friend, Professor, afterwards President, Drown (the successor of Nichols) and his associates and successors; or that of another friend, the late Professor Palmer, of the University of Illinois, whose chemical studies of the rivers of Illinois will long remain a monument to a life full of promise and too soon cut short; or that of still another friend, Professor Kinnicutt, who fortunately is still engaged in fruitful work.

I have perhaps said enough, though it would be difficult to say too much, of the magnificent contributions to public health science of Pettenkofer and his disciples in sanitary chemistry; but the work of these investigators in *sanitary physics* and especially the physics of the soil, of the atmosphere, of the walls of buildings, and of heating and ventilation, in their relations to the public health are quite as important, and perhaps to-day even more neglected. In view of the increased facilities of transportation and the growing habit of traveling, together with the tendency to outdoor life, which seem to be characteristic to-day of all civilized nations, the next twenty-five years will probably see a return to the patient and exact studies of *the environment*, such as the chemists and physicists began, and have in some measure continued, since the middle of the nineteenth century. These studies will be directed largely to further knowledge and control of the environment, but they will not end there, for *personal hygiene*, owing to recent advances in physiology, is to-day one of the most inviting fields for work and education, and I hardly need to point out to a company of experts

[1] William Ripley Nichols, address before American Association for the Advancement of Science, *Proceedings*, American Association for the Advancement of Science, vol. XXXIV, 1885.

that the proper care and right use of the individual human mechanism reacts favorably and fundamentally upon the public health no less truly or effectively than an improved condition of the environment or of the public health tends to promote the welfare and long life of the individual.

The sphere of hygiene may be divided, as it often is, into the two hemispheres, public hygiene and personal hygiene, or it may be cut into one portion dealing chiefly with the human mechanism and its operation (*personal hygiene*), and another portion dealing chiefly with the environment of that mechanism (*sanitation*). The time has gone by when any one person can safely undertake to deal with the whole sphere of hygiene. The physiologist and the physician must in the future leave to the architect and the sanitary engineer such subjects as housing, heating and ventilation, water-supply and sewerage, precisely as the sanitary engineer has never presumed to deal with foods and feeding, vaccines and antitoxins, exercise, sleep, and rest. The former subjects deal chiefly with the control of the environment, the latter subjects chiefly with the control of the individual, and sanitation and hygiene must henceforward be regarded as separate hemispheres of the science of health.

The *science of architecture*, if under this head we include the principles of building construction, and the heating and ventilation of buildings, has done and is doing much of interest and importance to the student of public health science. For my own part, I am continually more and more impressed with the fact that the air-supply, especially for the modern civilized and too often sedentary form of mankind, is in the long run quite as important as the water-supply, the milk-supply, or any other supply. Surely, we cannot be too careful of the purity of a substance which we take into our bodies oftener, and in larger volume, than any other, and which has come, rightly, no doubt, and as the result of long and painful experience, to be known as the very breath of life. I am well aware that human beings may survive and seemingly thrive, even for long periods, in bad air, but I am certain that for the best work, the highest efficiency, the greatest happiness, and the largest life, as well as for perfect health, the very best atmosphere is none too good. Hence I believe that the permeability of the walls of houses and other buildings, and the heating and ventilation of dwellings, school-houses, churches, halls, and other public places, require, and in the near future will receive, a much larger share of our attention than they have to-day.

In an age characterized by urban life and possessing sky-scrapers, tenement-houses, and other huge beehives, in which human beings aggregating vast numbers spend a large part of their lives, buildings require for their proper construction, lighting, heating, air-supply, water-supply, gas-supply, and drainage, the scientific services not only of architects, but of engineers, and such public buildings form one small section of the aid which modern *engineering science* is now everywhere rendering to public health science. The present has rightly been called an "age of engineering," and to no other science, excepting only medicine itself, is public health science to-day more indebted than to engineering science. I have referred above to the construction of the first municipal filter attached to a public water-supply as that of the Chelsea Company of London, constructed in 1829. How different is it to-day! Not only nearly the whole of London, but also Berlin and Hamburg, and a thousand lesser cities all over the civilized world, are now protected more or less perfectly from epidemics of typhoid fever, Asiatic cholera, and other water-born diseases, by vast municipal filters, ingenious and scientific in design and costly in construction, the work of skillful and faithful engineers, and monuments more precious if less enduring than brass to the contributions of engineering science to public health science. Innumerable storage reservoirs and vast distribution systems for supplies of pure water also bear witness to the enormous debt which public health science owes to engineering science, as do proper street construction and, still more, those splendid systems of sewerage with which so many modern cities are equipped, and which not only serve to remove quickly dangerous liquid waste of human and animal life, but also keep low and wholesome the level of the ground-water, reducing dampness and promoting dryness of the environment, and thereby strengthening that physiological resistance by means of which the human mechanism fights against the attacks of infectious disease. Nor do the services of engineering science end here, for the fluid content of the sewers must always be safely disposed of, and sewage purification is to-day a problem of engineering science no less important or difficult than that of water purification. These same processes of the purification of water and sewage are matters of so much moment in public health science that in almost every country experiment stations are now maintained at public and private expense for the purpose of working-out the most practical and most scientific methods of purification.

In no respect have the services of engineering science to public health science been more conspicuous than in the application and the further study of the principles involved in the processes of water purification. It has lately been shown, for example, that the introduction of pure water-supplies has in many cases so conspicuously lowered the general death-rate as to make it impossible to escape the conclusions (1) that the germs of a greater number of infectious diseases than was formerly supposed are capable of prolonged life in, and ready conveyance by, public water-supplies, and (2) as a promising possibility, that as the result of the greater purity of the water-supply the physiological resistance of the consumers of pure water-supplies is enhanced, in some manner as yet unknown; the net result being that the general death-rate is lowered to such an extent as to lead to a rapid increase of population in communities previously stationary or multiplying far less rapidly. In the case of the city of Lawrence, Massachusetts, for example, I have recently had the privilege of examining the results of studies by the distinguished hydraulic and sanitary engineer, Mr. Hiram F. Mills, which show that since the introduction of a municipal filter, which purifies the water of the Merrimac River supplying water to the citizens of Lawrence, while the population has increased nearly seventy per cent, the total number of deaths remains about the same as it was ten years ago. Mr. Mills concludes from the results of his studies — and I see no escape from his conclusions — that the introduction of the municipal filter has not only saved the lives of thousands of citizens, but has also caused the population to increase to a point much beyond any which it would have reached had the city continued to use, unpurified, the sewage-polluted water of the Merrimac River. A demonstration of this sort shows how easily the diminishing increase of population under a lower birth-rate may sometimes be counteracted without resort to that fish-like spawning which seems to be the only remedy of those who are terrified by "race suicide," so called. Moreover, it is hardly necessary to point out that such a diminishing death-rate means a far more rapidly diminishing morbidity rate — in other words, it means a heightened working efficiency of the population as a whole, and it must not be forgotten that for most of the results obtained in the scientific purification of water-supplies we are indebted to the science of engineering.

On the other hand, we must observe that engineering science, so far as water purification is concerned, is as yet only in its infancy and by no means thus far altogether satisfactory. In the United States, for example, in the last two or three years a number of epidemics of typhoid fever have resulted from the *defective operation or construction* of municipal filters, and while much has been done, it is clear that much still remains to do. In this connection it should be said that public health science in the United States suffers constantly and severely from an unsatisfactory condition of the science and art of administration or government in many American cities. Public health works are too often neglected, delayed, mismanaged, or built at extravagant cost, to the sanitary and economic damage of the people as a whole, and the tendency is far too common to place the care and operation of costly devices or systems in incompetent hands. I cannot here dwell, as long as I should like to do, upon the mutual relations of public health science and the sciences of legislation and administration. Speaking of my own country alone, I must confess that we are still very deficient in the applications of these sciences. We have not even a national board of health, although we have, fortunately, in the Public Health and Marine Hospital Service a strong substitute for one. The peculiarities of our democratic and republican government have hitherto made it impossible for the people of the United States to secure either from federal authorities or from more local sources that measure of paternal sanitary and hygienic protection which they ought to have, and it is the duty of every American worker in this field to bend his energies toward a better organization of the public health service in every direction, municipal and state as well as national. The appointment in 1886 of a distinguished hydraulic engineer to membership on the State Board of Health in Massachusetts marked an epoch, so far as America is concerned, in both sanitary legislation and administration. This appointment was a formal recognition on the part of the public of the necessity of a larger proportion of engineering science in matters relating to the public health, and the results have justified the new procedure. It is now, fortunately, becoming less rare in America to secure the services of engineers upon such boards, and there can be no question that participation of the expert laity with medical men is likely to be extended, probably far beyond our present ideas.

In a notable discourse before the International Medical Congress at the Centennial Exposition held at Philadelphia in 1876, Dr. Henry P. Bowditch, of Boston, one of the pioneers of hygiene and sanitation in America, divided the century then closing, as to its relation to public health science, into three periods, the first, from 1776 to 1832, a period of reliance upon authority and upon drugs; the second, from 1832 to 1869, a period of true scientific observation; the third, from 1869 onwards, an epoch in which the medical profession is aided by the laity and state hygiene is inaugurated. Dr. Bowditch has much to say of the desirability of a wider coöperation of the laity in state hygiene and remarks: "In all that tends to the promotion of state hygiene hereafter the laity will naturally and cordially coöperate with the [medical] profession." The history of public health science shows Dr. Bowditch's prediction to have been well grounded. The names of John Howard and Captain Cook in the eighteenth century, and of Edwin Chadwick, John Simon, and Louis Pasteur (not to mention a host of lesser workers) in the nineteenth century, show conclusively that public health science has been, even from the start, by no means confined to medical men. We may go further and say that even when forwarded by medical men these have seldom been busy practitioners. Sir George Baker and Jenner were, it is true, of this class, but not Pettenkofer, or Koch, or Ross, or Billings, or Reed.[1]

Reflections of this sort naturally lead to a consideration of the reciprocal relations of public health science and the science of education. I do not need to dwell upon the beneficial effects of public health science upon the hygiene and sanitation of school-children or school-houses. These benefits have long been emphasized by sanitarians and sanitary reformers and are sufficiently obvious. The reverse of the picture, however, is by no means so well understood. Unless one is familiar with the facts, it is difficult to conceive how little impression the splendid progress which the last fifty years have witnessed in public health science has as yet made upon the curriculum of education. From top to bottom and from bottom to top the schools, whether primary, grammar, high, normal, technical, medical, or any other class, are recreant, inasmuch as they neglect almost wholly any adequate training of their pupils in the principles of public health science which are confessedly of such profound importance to mankind. There is, to be sure, just now a popular wave of enthusiasm touching the extermination of tuberculosis, but in the United States, at any rate, both schools and universities are singularly negligent of their most elementary duties in this direction. Yet if what I have said before is true, if the laity are to participate from this time forward with medical men in sanitary and hygienic legislation and administration, if engineers and medical men in particular are to serve upon boards of health or in other executive positions connected with public works, then, surely, it is the duty of the science of education to lend its powerful aid and not to fail to save the lives and health of the people as these can be saved to-day, but always to promote that public health and that large measure of consequent happiness which can probably be more easily and quickly accomplished in this way than in any other.

As to the function of medical education and engineering education in respect to the dissemination of public health science, I shall say only a word. In spite of the reiteration by medical men of their belief in the importance of hygiene and preventive medicine as a part of the equipment of the medical profession, it is a significant fact that in America even the best medical schools devote very little time to any adequate instruction in these subjects. It may be that this is wise and that the pressing necessities of practical medicine forbid any extended instruction in public health science. I am willing to believe, if I must, that this may be the case; but if it is,

[1] "During the course of an epidemic, physicians are too busy to make observations which require much time or care, or to make more than brief notes." — *J. S. Billings.*

then the community must look for the most part elsewhere than to medical men for adequate investigation, legislation, and administration of public health science. Medical men, must, of course, always participate in the work, in connection, particularly, with the control of epidemics and in those forms of preventive medicine which have to do with vaccines, serums, and other means of modifying the vital resistance of the human body. But as regards the care and control of the environment, medical knowledge is not indispensable, and the entrance of the engineer and the sanitary expert upon the field, as foretold by Dr. Bowditch nearly twenty years ago, is to-day a conspicuous, and probably a wholesome, fact. As to the attitude of engineering education toward public health science there can be no question. If what I have said before is true, then engineers are bound in the future to take constantly a larger and more important part in public health work, and must be informed, and if possible trained, accordingly. Moreover, as regards both medicine and engineering, the problem is by no means insoluble, for a very short course of instruction rightly given would easily inculcate the necessary fundamental principles, while electives or post-graduate work might enable those few whose tastes led them in this direction to investigate and specialize and more thoroughly prepare themselves for public service.

I cannot treat, nor do I need to treat, as thoroughly as I would be glad to do, the mutual relations existing between medical science, especially the science of medical bacteriology, and public health science. These are already sufficiently obvious and well known. From time immemorial medical men have served, often devotedly and sometimes heroically, in the cause of public health science. I take it, however, that since we have in this Congress and in our own department a section of preventive medicine, I may pass over without comment this part of my subject.

As regards sanitary bacteriology, however, the relations existing between this and public health science are so fundamental, so extensive, and so important, not only on the medical, but also on the engineering side, that although we have also in this Congress under the department of biology, as is entirely proper, a section of bacteriology, I may linger at this point for one moment. The bacteria and other microscopic forms of plant and animal life, all of which are conveniently included under the term microbes, have so lately begun to be understood and appreciated that we must still emphasize their extreme importance. The discoveries of the botanists and zoölogists and revelations of the microscopists in this domain are comparable, in their importance to public health science, with nothing less than the revelations of the telescope to astronomy. Astronomy had, indeed, existed long before the invention of the telescope, and public health science, as we have shown above, had its beginnings nearly a century before any considerable progress had been made in micro-biology. But it is not too much to say that the developments in micro-biology since Pasteur began his work have not only revolutionized our ideas of the nature of the infectious diseases, but have also placed in our hands the key of their complete control.

Concerning the relations of *physiology* to public health science, I must not fail to speak. Here is a field absolutely ripe for the harvest, but one in which the harvesters are as yet very few. I have lately had occasion to examine somewhat carefully the present condition of our knowledge of personal hygiene — which is nothing more (and should be nothing less) than the applications of physiological science to the conduct of human life — with the result that I have been greatly impressed with its vast possibilities and promise. Man is a gregarious animal, and mankind is to-day crowding into cities as perhaps never before. Moreover, the industrial and commercial age in which we live is characterized to an extraordinary degree by the sedentary life. Yet the sedentary life is almost unavoidably an abnormal life, or at least it is a life very different from that lived by most of our ancestors. In the sedentary life the maintenance of a high degree of physiological resistance apparently becomes difficult, and if the vital resistance of the community in general is lowered, then the public health is directly and unfavorably affected, so that considerations of personal hygiene have a direct bearing upon the science of public health.

There are, to be sure, interesting and suggestive symptoms of a wholesome reaction, in America at any rate, against the evils of the sedentary life. Parks and open spaces are being liberally provided; public and private gymnasiums are rapidly coming into being; public playgrounds are thrown open in many of our cities, free of expense to the laboring, but, nevertheless, often sedentary, population; vacations are more than ever the fashion; sports and games are everywhere receiving increasing attention; while public baths and other devices for the promotion of personal hygiene are more and more coming into being. All this is as it should be, but all is as yet only a beginning. Here, again, the science of education is sadly at fault and in the direction of educational reform as regards personal hygiene lies immense opportunity for a contribution to public health science.

The science of *statistics*, which has done great service in public health science in the past, is likely to do much more in the future. Without accurate statistics of population, mortality, and the causes of sickness and death, the science of epidemiology is impotent, and the efficiency or inefficiency of public health measures cannot be determined. And yet in ignorant hands statistics may be worse than useless. It is a matter for congratulation to Americans that we now have in Washington a census bureau permanently established and under expert supervision, but until the various states and cities of the United States follow this excellent example of their Federal Government, one of the most important aids to public health science will continue to be wanting, as is unfortunately too often the case to-day not only in America, but in many other parts of the civilized world.

PUBLIC HEALTH: ITS PRESENT PROBLEMS

BY ERNST J. LEDERLE

[**Ernst J. Lederle**, Consulting Sanitarian, New York City Department of Health. b. Staten Island, New York, 1865. School of Mines, Columbia University, 1886. Ph.B. Ph.D. 1895; D.Sc. 1904. Chemist of New York City Department of Health, 1888–1903; Commissioner of Health, New York City, 1902–03. Member of American Chemical Society; Society of Chemical Industry; Verein der Deutschen Chemiker; New York Academy of Sciences, etc.]

In expressing my thanks for the honor which the organizers of this Congress have done me in the assignment to speak upon the subject of "Public Health: its Present Problems," I find two reasons for so doing. The sense of personal gratification of course enters into my acknowledgment, for it is a pleasure to feel that one's efforts for sanitary reform, however slight in comparison with those of many who will address you, are appreciated beyond the limits of the city where those efforts were put forth.

It is an inspiration to the worker to find that whatever is of value in his work is eagerly observed, taken up, and adapted to conditions as they are found in other parts of our country. Perhaps the most interesting and valuable recollection I have of my work in the sanitary service of New York City is that, in the course of that work, I was able to gain from my co-workers in other cities fully as many ideas for sanitary betterment as we in New York could give. The effect of such coöperation is to make one realize that sanitary reform work is not local, not even national, but world-wide; and that every worker in its cause may draw at will upon the resources of his fellows while he gives them of his own.

But the personal pleasure I feel in speaking on this topic is subordinated to another consideration. The fact that it should have been assigned to any but a physician seems to me to be of much significance.

Sanitary science has been, for so much of its brief existence, set forth almost wholly by medical men, that it is still widely regarded as their peculiar province. And properly so; the very nature of his training and occupation makes the intelligent physician find in unsanitary surroundings a predisposing cause of disease; and his work has been and will continue to be so to improve sanitary conditions as to minimize and finally to eradicate a great many diseases which still make up a large part of the annual mortality.

Preventive medicine is the watchword of the new school. It is a sign of the progressiveness of that school that, in all enlightened communities, it has now realized the great scope of the preventive work to be done, and has called into existence a new profession, that of the sanitarian, in order to have the aid of specialists in hygiene in solving the problems of disease.

Modern public hygiene, in fact, has passed the point where the overcrowding of population has made prompt solution of sanitary problems imperative, there are many questions of administration and policy to be solved, and for these the physician ordinarily has little aptitude. His experience and training are rarely, if ever, of the sort to make him a successful administrator. I do not by any means seek to maintain that this function resides wholly in the sanitarian, so called; far from it. But in the adaptation of means to ends, in the countless circumstances of administrative duty which public service entails, a layman, with skilled medical advice upon purely medical questions, seems to me better fitted to accomplish results than the physician alone.

This leads me to a statement of what I believe to be the best possible organization of a sanitary service, municipal, state, or national, and one which I hope some day will be adopted not only in cities and states, but by our Federal Government. At its head should be a board of administration, consisting of a physician of the first rank, skilled in the application of bacteriological and general medical research to the problems of hygiene; a trained sanitary engineer; and third, if you like, as a balance-wheel to prevent the eccentrics of the specialists from disturbing the workings of the machine, a man of affairs in the broader sense of the word, who should be versed in sanitary practice and, at the same time, chosen mainly for administrative skill and for a certain practical common sense which might guide such an organization wisely, and, perchance, prevent misuse of the great powers with which it ought to be endowed. In the service of such a department of our government, there should be a staff of specialists in every branch of medical and sanitary science, laboratories equipped for research and diagnosis, and all other adjuncts which make for efficiency in public hygiene. One may question how such a body would be regarded by the existing sanitary authorities of cities and states; but, to my mind, it would be entirely feasible to coördinate all the minor divisions of sanitary service into one comprehensive whole, in which the central body, though maintaining its position of leadership, should exercise police powers with extreme caution while developing its advisory function to a degree of usefulness beyond any yet attained.

Those who see in such a plan an unwarranted extension of federal power might profitably study the workings of such organizations as the Kaiserliches Gesundheitsamt in Germany and the union of British medical officers of health. Particularly in the former are the beneficial effects of centralized authority evident. Our own government's centralized activity along such lines as that pursued by the Department of Agriculture is proving its value as an educational factor to our population beyond all question.

There seems to be no good reason why a similar organization for sanitary work should not be instituted. Its beginnings are to be found in the work of the Bureau of Animal Industry of the Department of Agriculture, which has already demonstrated its efficiency in enforcing interstate quarantine upon infected cattle, as well as in other ways too numerous to mention. Another governmental effort, conceived in the same scientific spirit, is to be seen in the founding of various state agricultural experiment stations, which are practically chemical laboratories working upon problems which the farmer, without scientific aid, might never be able to solve.

Federal establishments like these, for the study of hygienic problems and the betterment of health in sections of the country where such betterment is sorely needed, would have an immense educational value, besides conducting great works of sanitation on broad lines where now such work is either entirely neglected, or allowed, for the most part, to fall between the two stools of municipal and state sanitary authorities. Such a central body would also solve the vexed questions of national quarantine, which are now left to the varying judgment of local health officers in our seacoast cities, at times undoubtedly to the menace of the public health of the United States.

Another field of usefulness for a national board of health would be the training of sanitary officers. Sanitary science is so new, and the public appreciation of its benefits still so small, that the rewards for the pursuit of it as a life occupation are not sufficient to induce enough good men to make it a study. The result has been, thus far, that the men who do the actual work of sanitary inspection, even in the service of well-organized bureaus of health in the large cities, are as a class without other training than that which experience and, at best, a little reading on sanitation can give them. They may have been plumbers or carpenters before entering public service, but none of these bring any great amount of theoretical knowledge to their work. A few, of course, have been educated as physicians, but have turned to the sanitary field for one or another reason; often, perhaps, it is to be feared, because the certain small salary in the public service is more satisfactory than the doubtful rewards of more or less unsuccessful medical practice.

Some time ago, seeing the need for attracting to the pursuit of sanitation men of higher grade than the majority now engaged in it, I suggested to the president of one of our largest universities the plan of offering courses in hygiene and sanitation as part of the curriculum. He replied that the experiment had been tried, but that few or no pupils presented themselves; he thought that young men inclined to pursuits of this character chose rather the courses which would fit them for engineering, civil or mechanical, and he therefore advised that studies of this character might more profitably be offered through the medium of night schools and the like.

This was evidence to me that young men of the class which can afford a university education aimed at higher pecuniary rewards than are now afforded to workers in hygiene; it was also evidence that wider efforts should be made to demonstrate the great public need of educated sanitary officers, and the great opportunity the practice of hygiene affords for valuable public service. I believe that, in time, we shall have in this country a class of educated public sanitarians; but that time will not come until scientific work of this character is adequately paid for, and it will come sooner if the sanitary bodies in various states and cities, now working along independent and often conflicting lines, are coördinated and made a part of the greater activities of a national board of health, deriving its powers as do other main branches of the Federal Government.

To define the present problems of a modern board of health is to classify and describe its multifarious activities. Broadly speaking, of course, its main objects are to prevent the spread of contagious disease, and to enforce sanitary ordinances; but to these have been added, some may say "arrogated," so many other powers and duties that the sanitary officer of a generation ago would have great difficulty in understanding the scope of the work to-day.

Public opinion, in the last analysis, is responsible for the extension of these powers. The expansion of sanitary police functions, especially in the suppression of nuisances, has resulted from the growth of public opinion as to what constitute nuisances; forty years ago what we now define as "offensive trades" and relegate to certain prescribed sections of New York City flourished on many of the best streets. The force of public opinion has gradually branded one nuisance after another as "detrimental to health," and driven them to places where they are no longer an offence to the nostrils, the eyes, or the ears. Power to affect these removals, and to keep sources of nuisance under observation, has been given to boards of health in continually increasing measure, because the public has found that in the great majority of instances powers previously delegated had not been abused. It is this support of public opinion which has in recent years so increased the authority and multiplied the duties of sanitary officers.

Thus supported and uplifted by the public which they serve, the greatest of all the present problems confronting boards of health in this country, I have no hesitation in saying, is the responsibility of preserving the sanitary service from the evils of partisan politics.

The politician is nearly always the bitterest opponent of sanitary reform, because nearly every order for sanitary betterment touches the pocket of some of his constituents, who immediately run to the politician for relief. How important, then, from the standpoint of practical politics, it is that the party in power (I speak particularly of our cities) should have control of the sanitary officers and use their great authority to help friends and injure political foes. If the politician controls the sanitary officers, he controls the appointment of all subordinates, and soon demonstrates to them that he and not the nominal head of the sanitary office is the man to come to for instructions. When this occurs, the usefulness of a board of health is ended, and its maintenance is money thrown away, if not worse. Then, too, even if the office is not wholly in control of the politicians, they sometimes are able to secure the alteration or even the nullification of important orders, and the inevitable result is injury to the public that private interests may profit. The extension of the civil service law has made the subordinate sanitary officers in many cities independent of politicians' threats if they choose to be; but it does not so favorably affect the more important activities of sanitary bureau heads, who are still too much controlled by the appointing power. There will never be a radical improvement in this condition until our sanitary offices are taken entirely out of politics, and the incumbents appointed for life or during good behavior.

How to prevent the spread of infection will always be one of the chief problems for sanitary officers, and it continually presents new phases, new difficulties, as the density of population in great cities increases. This is particularly true of our seaboard cities, where there is a constant influx of immigrants, latterly of a class which is ignorant of the rudimentary principles of sanitary living, and of grossly filthy personal habits. These people have been dumped upon our coasts in swarms, several hundred thousand annually coming to New York City alone. Students of the immigration problem state that the more progressive elements of this new population move westward to take up unoccupied farm-lands, or find work in mines or mills, and that the most ignorant remain in the cities. We of New York can well believe this. After all, the enforcement of sanitary laws is bound up in the education of the ignorant and filthy to the objects of such laws; and so it is necessary for the sanitary authorities of New York and other maritime cities to carry on a never-ending campaign of education, in populations constantly renewed at the bottom of the ladder.

But new peoples are not merely ignorant and dirty; they often bear seeds of disease. The Federal Government has up to this time made no provision for the care of contagious sick immigrants in the largest American port, but has relied wholly on the local authorities for their detention and treatment. Two years ago we found that the sick immigrants were so crowding our contagious disease hospitals (then notoriously insufficient to care for New York's own contagious sick) that many citizens, who should have had first claim to attention, were being excluded. We notified the federal authorities that they must at once make preparations to isolate and treat contagious sick immigrants without the use of the city hospitals; and the result has been that the Government is building an island in the bay for isolation hospitals.

Much mischief has resulted from former lax medical inspection of immigrants, extending over many years. New York, and, I doubt not, other seaboard cities, are to-day troubled with many cases of contagious eye-disease, originally brought from Europe by immigrants and by them transmitted to their fellows in the East Side tenements, who are some of them only a degree less filthy than the new arrivals. To stamp out this disease will be the work of a generation, if not more, for its spread has been till lately entirely unchecked by the sanitary authorities, and its victims probably number many thousands.

It has seemed to us in New York that the best means of checking the spread of contagious disease, of which trachoma is only one comparatively unimportant element, was through the public schools. One of our leading sanitarians has well said that schools are the foci of infection. This is amply proved by a study of the reports of infectious disease cases in large cities; almost invariably the number of cases begins to increase with the assembling of pupils in the autumn, and continues large so long as the schools are in session. Rigid medical inspection in the schools is therefore absolutely necessary, and its advantages are manifest, for in New York City (which I may safely say has now the most highly developed system of medical school inspection in the country) the elaboration of the present method two years ago resulted in a diminution of contagious disease cases amounting to about 40 per cent. Incidentally, also, the death-rates of 1902 and 1903 fell to a point never before reached in the history of the city; with the lessened mortality among children particularly marked.

This system entails extreme care and considerable expense, for it demands the services of a competent medical inspector daily in every public school in the city.

His work is to exclude from the class-rooms all children under suspicion of infectious disease, and to notify the school authorities of the exclusions, with the reason for each, in order that exclusion may not be mistaken by them for truancy. At this point the diagnostician's work ends, and that of the school nurse begins. The nursing system was adopted with a view of providing minor medical attention for excluded children and of carrying into the tenement homes some elementary idea of the proper care of the sick, as well as incidental instruction in household sanitation. The school nurse is an adaptation of some of the principles of settlement work to the problem of handling school exclusions for minor contagious ailments, and, when she is a woman of experience and a graduate of some recognized training-school, as we require in New York, the successful results of her work are instantly manifest. One nurse can handle the exclusions from four or five schools, averaging from 500 to 1500 pupils each.

It is not required that the nurse shall give any attention to cases of contagious disease, such as scarlet fever, diphtheria, measles, and the like. That is and should be left to the ordinary operation of the bureau of contagious diseases, which has its established corps of diagnosticians and district medical inspectors. The routine handling of such cases involves, first, a rigid enforcement of rules regarding notification by the family physician of all contagious cases coming under his observation; second, the confirmation of the diagnosis by an expert medical inspector and his decision whether the case can be properly isolated in the home, or whether removal to the isolation hospital is necessary; third, the enforcement by the district medical inspector of the rules requiring a continuance of isolation during the full period of the disease.

Proper handling of a contagious disease bureau requires not only good judgment and strict obedience to department rules by medical inspectors in their work, but a well-organized system of keeping the records of all cases within the purview of the bureau. Another important aid to successful operation is the transmission daily to all school principals, teachers, librarians, and other persons having charge of children in ordinary places of assemblage, of complete and accurate lists of all contagious cases reported, and of the termination of other such cases and the disinfection of premises. This puts such persons on their guard, and undoubtedly checks the spread of contagion.

In spite of the enormous preponderance of evidence in favor of vaccination, we cannot deny that the prevention of small-pox is still a problem for local boards of health. I say local, for the handling of small-pox varies so greatly in different communities that the efficiency of one is often largely nullified by the neglect of another. Here again is a strong argument for centralization of disease-preventing and sanitary work under the control of a federal bureau. For example, in the first months of 1902, we in New York were confronted with an outbreak of small-pox which amounted almost to an epidemic. The disease was equally prevalent in other eastern cities. In that year, by vigorous effort, free public vaccination was performed upon nearly 25 per cent of our population of 3,500,000 persons, and there is reason to believe that private vaccinations reached an unusually large total, due to the alarm of the inhabitants over their danger, which was purposely not allayed by the sanitary authorities. In fact there was a genuine public awakening to the need of vaccination.

Cases of small-pox that year in New York numbered some 1900; the next year they fell to less than 100, although the disease continued very prevalent in many neighboring cities where there had been no determined effort to stamp it out. One result of this variation in practice was that New York was constantly visited by sporadic outbreaks of small-pox, brought from other cities. Fully half the 100 cases in 1903 were either of immigrants newly arrived from Europe or visitors from infected cities in the interior of the United States.

I believe that compulsory vaccination, so-called, is not necessary in most parts of our land. It may be demanded in countries having a less intelligent population than ours; but we of New York have found that we needed only to arouse public opinion on the necessity of vaccination to secure the results we wanted without any compulsion. Vaccination is a requirement of entrance into our New York public schools, and we have not, in my recollection, had a single case of small-pox in the schools so protected; but compulsion exercised upon adults often serves unnecessarily to arouse public feeling against the sanitary authority, and gives a handle to those ostrich-like scorners of facts, the anti-vaccinationists.

If we compare the variation in methods of contagious disease prevention as between the large cities and the small towns and rural districts, we find that in the latter few of the precautions taken in the cities are exercised in the country. This results from lack of proper facilities for isolation, and this lack is due to public indifference on the subject; for if the public realized how much the spread of disease could be checked by these means, provision for isolation hospitals and competent medical inspectors would be one of the first items of expenditure in their annual budgets.

As it is now, only the most intelligent of our secondary city governments make adequate provision for their contagious sick. Many others, of course, have buildings intended for that purpose, but these buildings too often consist of miserable shanties in the outermost confines of the city or village, and the inhabitants complete an ill-conceived work by calling these buildings "pest-houses" and thus branding them as places of horror to be avoided by every possible means. Such isolation hospitals destroy the value of property in the neighborhood.

Contrast such places with well-ordered isolation hospitals like those maintained in some of our smaller eastern cities, notably in New England, and the observer must realize that patients there treated not only have far better chances for recovery than if kept in the ordinary home, but that they cease to be a source of danger to the community.

Until such handling of contagion becomes general in our country, negligent communities will continue to nullify the efforts of those which take proper care of their inhabitants. If the stimulus to such action came as an order from a federal board, having jurisdiction and punitive powers throughout the country, the popular knowledge on this subject would grow more rapidly, and the popular conscience would be more quickly awakened.

Discovery and development of the serum treatment for certain infectious diseases, notably diphtheria, has in the last ten years brought new problems to sanitary officers, both in practice and research. It may safely be said that the labors of the bacteriologist have in this time done more than any other one thing in the prevention of infectious disease. Speaking as a layman, of course, I am led to believe that preventive medicine will in the next generation make its greatest progress along the lines of bacteriological research. We are on the eve of still more important discoveries in this direction, and it would not be rash to predict that serums for the successful treatment of tuberculosis, pneumonia, and scarlet fever will be the next great steps. The importance of such results it is impossible to exaggerate.

Consider for a moment the beneficial effects already attained by the anti-diphtheritic serum. I may cite the work of New York City, where the work was first instituted in this country, and where it has been most highly developed. In 1893, New York's case-fatality from diphtheria was 36.4 per cent, and in 1894 it was 29.7 per cent. New York having in 1892 established the first bacteriological laboratory under municipal control, the preparation of serum for diphtheria treatment was begun in 1894, and in 1895 the distribution of this serum was begun. It was given free to all public institutions and to all persons who certified, through the attending physicians, that they were too poor to pay the price charged for it, which was fixed at a point only high enough to cover the cost of manufacture and incidental expenses of the laboratory; a staff of medical inspectors was also designated to administer the antitoxin free upon request of an attending physician.

In that year, due almost entirely, I am convinced, to the use of this new remedy, the case-mortality fell to 19.1 per cent, and it has steadily decreased until in 1903 it had fallen to 11.1 per cent. It is now the practice also to administer immunizing doses of antitoxin to healthy members of a family having a case of diphtheria, and in the last eight years upwards of 13,000 persons have been so immunized by department inspectors and family physicians. Of the persons so immunized, .3 of one per cent contracted the disease, and one case terminated fatally. Could any stronger testimony than these figures be offered as to the efficiency of diphtheria antitoxin in the cure and prevention of the disease?

Naturally enough, such results have led to the establishment of other laboratories for the preparation of this serum. Some are maintained by state authorities, notably in Massachusetts, but the larger ones are now under private auspices.

High prices are charged for serums by manufacturing chemists, and there is no means of testing their efficiency comparable to the records of public laboratories. It therefore would seem to be a reasonable precaution, in the interest of the public health, that these private laboratories should be placed under strict governmental supervision and control, if, indeed, the manufacture of serums should not be one of the functions of a national board of health, organized according to plans which I have mentioned, and which are by no means novel. Products of public laboratories might be distributed free or at small cost, and thus be made far more effective in the prevention of disease, while control of the laboratories by recognized sanitary authorities would be a more satisfactory guarantee of the potency and uniformity of their serum products. A highly organized governmental laboratory service would also offer splendid opportunities for research work in a field the enormous importance of which few people are yet in a position to realize.

One of the most hopeful signs of progress in popular appreciation of sanitary endeavor is the general interest now awakening in methods for the prevention of tuberculosis. Medical men are everywhere agitating for better facilities to fight this disease, the worst enemy of the human race, and lay associations are taking steps to establish sanitariums for the reception of patients. This work is a stupendous one, and we have thus far only touched its edge. Efforts to discover a serum for the cure of the disease, though thus far disappointing, have already much increased medical knowledge of the subject.

It is not enough that the world should wait on the researches of the bacteriologist. Our cities are full of consumptives, spreading infection among their fellows in spite of all efforts of the sanitary authorities to instruct them in personal precautions. We must have sanitariums and hospitals of large capacity for the reception of cases in all stages of the disease. The cost will be great; but tuberculosis claims most of its victims at a time when their usefulness in industrial pursuits is greatest, and it can be amply proved that the cost of their care and cure would be small indeed in comparison with the loss the community suffers by being deprived of their services. Money spent in erecting and maintaining sanitariums would be saved in almshouses and orphan asylums.

Even when such places of reception for consumptives are afforded in anything like sufficient measure, there will still be a large class of infected wage-earners who cannot leave their regular occupation because their earnings are needed to support dependent members of the family. For all such the sanitary authorities must exercise greater care. This is one of the great objects in improving the conditions of labor, the ventilation and sanitation of factories and workshops, and the improvement of the tenements in which people of this class are forced to live. Equally must the conditions surrounding child labor be the subject of still further investigation and regulation.

Development of the cognate science of vital statistics is highly important in the study of methods for the prevention of disease. It helps to measure progress and point out the next steps necessary. But its aim is of course far wider than this; the record obtained by this registration system are of basic importance not only to the sanitarian, but to the student of sociology in all the ramifications of his work, in political economy, geographical race distribution, education, etc. Add to this their importance in private affairs, where they are often the final arbiters in disputes over titles and inheritance, and we have ample reason for using the proceeds of taxation liberally in developing the work of the vital statistician.

In no respect have the powers and responsibilities of boards of health developed more in the last generation than in the regulation of public nuisances. I refer particularly, of course, to the regulation of nuisances in cities, because the increase of population in restricted areas in cities has in itself created new sources of nuisance and brought new problems for solution by the sanitarian. The greater demand for comfort in city life, and the realization that the public health is in large measure dependent upon a restriction of many things which in the past have made for discomfort, have led to the institution and enforcement of a new body of sanitary ordinances of a scope not dreamed of even as recently as twenty years ago. These have almost revolutionized sanitary practice and have added enormously to the powers and duties of sanitary officers.

It is noteworthy that the public demand for relief in this direction has greatly expanded the list of nuisances which have been placed under sanitary control. To the duty of protecting the public health has been added that of protecting the public comfort. For example, I imagine it would be very difficult for sanitary officers to prove on the trial of every case that a smoke nuisance is directly injurious to the public health; yet so strong is public opinion in favor of enforcement of this ordinance that the sanitary authorities who proceed vigorously under it have little difficulty in suppressing such nuisances, even when the prosecution of offenders reaches the municipal courts.

This is all a very new development in sanitary practice. The growth of manufacturing by steam-power in large cities has greatly increased the use of coal in boiler plants of large capacity. Of late, because of the higher prices for anthracite, the use of bituminous coal for manufacturing purposes has come into vogue. Imperfect combustion, the result of careless firing, creates a nuisance. Suppression of this nuisance should not be confined to arrest and punishment of the offenders; instruction in means to avoid nuisance should accompany it.

Akin to the smoke nuisance is that from dust. Bacteriological study has shown conclusively that dust is a carrier of disease-germs, and therefore a menace to public health. Here is the greatest argument for clean streets and for improved methods of cleaning them. In the New York tenement districts we have had great success from the general use of asphalt pavement, which can be washed with a hose, and so cleaned without raising dust. The great thing in getting rid of dust is not to *move* it but to *remove* it. This applies to the dust problem in houses, and in theaters, schools, churches, and all other places of public assembly. Such places in New York were a year or two ago, under our instructions, first brought under general sanitary inspection, with excellent and rather remarkable results, considering how large a number of orders we had to issue to have them put in proper sanitary condition. This work may be well adapted to a countless number of public and semi-public buildings in cities, for the places which every one year after year assumes to be in fairly good condition are often the ones which really demand most careful attention from the sanitary authorities.

As a vehicle for the transmission of the germs of tuberculosis, dust in places of public occupancy, like railway and street-railway cars and ferry-boats, should be rigorously fought. The matting and carpets upon the floors of public conveyances are sources of danger, and should either be done away with entirely or cleaned and fumigated at frequent intervals. Our American habit of spitting everywhere but in proper receptacles, undoubtedly conveys infectious disease, and every city should pass and enforce an anti-spitting ordinance. New York has had a course of public education in this respect, and the nuisance is very greatly reduced, although hundreds of men, some of them intelligent enough to know better, figure in the police courts every year as prisoners on this account.

Noise, as an element of public nuisance, demands increased attention from the sanitary officer. Its injurious effect on the health of individuals is beyond question. But the authorities must distinguish carefully as to whether a particular noise is a public or merely a private nuisance, and whether it is a necessary concomitant of something of public utility.

Noise nuisances in connection with public utilities are in some sense necessary. In cities the trolley-car is often a source of nuisance to the inhabitants of the streets through which it passes, due to excessive ringing of bells, and the operation of cars with unevenly worn wheels. Both these nuisances can be minimized, either by calling the attention of the railway operators to them, or, failing relief, by prosecution in the courts. The use of flat-wheeled cars is as much a waste of power and equipment as is imperfect combustion of fuel, and, in the interest of the public health, should be suppressed with equal severity.

Offensive and dangerous trades also call for attention by the sanitary authorities. Most cities which have given proper care to this subject have restricted their offensive trades, such as slaughter-houses, gas-plants, and the like, to certain areas, and allowed their operation only under permit from the board of health, revocable for violation of the sanitary ordinance. This system appears to work very satisfactorily for the public, so long as the sanitary officers are neither negligent nor venal.

It is an interesting fact in connection with the handling of nuisances of this class that many improvements demanded by the sanitary authorities, such as the inclosing of rendering-vats to prevent the escape of ill-smelling vapors or the collection and removal of nuisance-making liquid refuse, have in themselves resulted in cheapening manufacture; the discussions of methods for the innocuous removal of such waste matter has opened the way for its profitable employment for the making of one or more of the numerous by-products out of which large profits are gained.

These results might never have been achieved without the correctional action of the authorities.

The time has passed for the establishment of any of the so-called offensive trades within the built-up portions of cities. Existing plants should be gradually removed, with due regard to the vested interests involved, and no more should be allowed to come in. Railway transportation of dressed beef has become so general that there is no longer any excuse for the building of slaughter-houses in eastern cities. Not only is this best on economic grounds, but the transportation of live-stock for longer distances than absolutely necessary is to be opposed on medical and humanitarian grounds. Neither is there any reason, but the inertia of their owners, for the maintenance of manufacturing plants in the midst of cities, and their establishment should be vigorously opposed by the sanitary authorities.

The so-called dangerous trades offer a field thus far little worked by the sanitarian in this country, although the subject has had much attention abroad. Here we have hardly any legislation under which the sanitary authorities can take radical action to safeguard the life and health of persons employed in those trades, and therefore they may hardly be said to be under official control. There are many trades, however, in which the ordinary processes of manufacture induce disease, and others also which offer means for the spread of infection. All will repay study by the sanitarian, with a view to remedial legislation.

Jurisdiction of boards of health over public supplies, such as water and milk, is already well developed in some states and cities, and much valuable work has been done in respect to the sanitary purity of these necessaries of life. Negligence by the public authorities, however, is still resulting, year by year, in outbreaks of typhoid and other enteric troubles communicated in impure water or milk. For evidence of this we have recent typhoid epidemics in Ithaca and Watertown, New York, and Butler, Pennsylvania.

The very rapid growth of our cities and towns and the improper disposal of their sewage are causing general pollution of many water-sources, and making it more difficult either to find pure water-supplies or to keep existing supplies safe from infection. The only remedy for this increasing menace is filtration, and that on a large scale and under constant supervision by sanitarians and bacteriologists. This work is very costly, but its maintenance after the installation is complete will amply repay the expense, in the saving of life and the preservation of health. Equally important are precautions for the treatment of sewage. Bacterial purification of the liquid refuse of cities and towns is now coming into use, with salutary effect; but too often municipalities which have installed such systems imagine that their work is done, when in fact such methods of sewage disposal require constant expert attention in order to insure their maximum efficiency.

Thorough sanitary control of watersheds involves not only the removal therefrom of all possible sources of infection and the preparation of reservoirs by the elimination of all decaying vegetable matter; there is also demanded an efficient, unremitting inspection of all sources of water-supply, with frequent chemical and bacteriological examination of the water itself. Statistics gathered in the course of such investigations are all-important in tracing the nature and sources of pollution. The extension of existing watersheds and the taking of new ones, to meet the demand for more water due to the growth of our cities, make such investigations imperative for the maintenance of the public health. Coöperation between state and municipal authorities to this end has already been productive of much benefit, and for this reason it is highly important that these two divisions of sanitary workers should operate in accord; even better results might be achieved if they could be coördinated under the control of a national sanitary body.

Bacteriological disclosures of the transmission of disease-germs in milk, and of the dangers resulting from improper handling of this product, have brought it more firmly under sanitary supervision. The first step in the cities, of course, was to bring all milk-dealers within the control of the board of health by prohibiting the sale of milk without a permit. The next was to revoke permits when milk found on sale fell below the standard adopted. It was frequently found that the retailer was the innocent victim of an unscrupulous wholesaler or shipper, consequently it became necessary for the municipal sanitarian to reach out into the country districts and investigate the conditions at dairy farms. With the investigation went some instruction in methods of producing clean milk, by which the honest farmer might profit. The establishment of model dairy farms by men of wealth has also taught by example, and the high prices obtainable in city markets for high-grade milk have stimulated the farmer to continually greater effort. With this campaign of education has come a demand on the railways for the proper icing of milk-cans in transit.

Milk is a most favorable medium for the propagation of germ-life, especially at temperature above 50° Fahrenheit. In this condition it is often found to have a toxic effect, particularly when used for infant feeding; consequently failure on the part of the sanitary authorities to prevent the sale of such milk has the immediate and direct result of advancing the rate of infant mortality.

Regulation of the sale of other foodstuffs has been less highly developed. In some centres there has been established a fairly efficient system for the inspection of beef cattle, but there is no doubt that the meat of tuberculous animals is sold in considerable quantity in all our large cities. Scientists have not yet definitely determined whether or not tuberculosis can be thus transmitted to human beings, but there is still adequate reason why the sale of infected beef should be absolutely stopped and the sellers punished.

The danger of typhoid infection through the medium of shell-fish is now so well established that we need have no question of it at this late date. No more clean-cut instance of this can be found in all medical history than in the epidemic of typhoid fever at Wesleyan University ten years ago. Investigation by Professor Conn and others demonstrated conclusively that the disease had its origin in Fair Haven, where the oysters eaten by these Wesleyan students had been fattened in an infected stream. It may be noted also that recent experiments in the bacteriological laboratory of the New York Department of Health have tended to show that the icing of infected shellfish does not destroy the virility of the germ-life therein.

With these facts accepted, what excuses the sanitarian from maintaining a most careful supervision over the culture and sale of shellfish? Especial attention should be given to the so-called "fattening" process, which is most often conducted in the brackish waters of streams adjacent to tidewater. The liability to infection in such waters is too obvious for argument, and the fattening process should either be stopped, or restricted to locations where there is no danger of pollution.

An important field is now opening to the sanitarian in the investigation of manufactured food-products. The extent to which commercial adulteration and substitution is now practiced would be absolutely incomprehensible to the layman. Competition in trade has become so keen and the substitution of inferior constituents in foods so general that the honest manufacturer has hardly a chance to succeed. Even to name a small part of the many frauds of this character would consume more than the time allotted to this paper. The use of injurious preservatives has also been practiced to a scandalous extent. The only remedy for this evil condition will be the passage and enforcement of a federal pure food law; such a measure has already been before Congress, but in the absence of an aroused public opinion, the mysterious influences which bar the way of much good legislation at Washington have been able to kill it. Several of the states already have pure food laws, and a beginning has been made under them, but this reform will only come after one of the longest and hardest fights which the public sanitarian has ever known.

Much the same opportunity is offered in a campaign against the vender of patent medicines and secret nostrums. Few people understand the extent to which these articles undermine the public health, and there has been little or no attempt to assume official control over their production and sale.

These nostrums are of several kinds. Some of them are prescriptions which have been commercialized by some sharp business-man, with all the help of advertising and guarantees of the remedy as a "cure-all." Gullible people, who seem to be legion, are led into the error of imagining that all diseases of the same general description will yield to the same remedy; they fail to recognize the important factor of idiosyncrasy, and the result is that nine out of every ten persons using such a remedy are not helped and may be injured in health, as they surely are in pocket.

In this class of nostrums must be ranked the various headache powders, now for sale everywhere. Almost invariably these contain drugs which should only be prescribed by physicians, and then only with extreme caution.

In another kind of nostrums the active principle is some powerful drug or stimulant, the use of which speedily becomes a vice. For example, many so-called catarrh cures have cocaine as their active agent; others, again, which are advertised to cure every ill, or to break the user of the liquor habit, are loaded with alcohol, which produces a passing stimulation, but leaves the patient in worse state than before. All these are swindles of the most dangerous character, and it is the plain duty of the public health officer to secure their suppression.

The official chemist is called upon also to investigate and stop the sale of impure and substituted drugs. It is not too much to say that the drug trade is flooded with such deceptions on which the public is being worse defrauded year by year, as the evil grows.

The remedy is official control. Makers of patent medicines, nostrums, pills, etc., should be required to place upon each bottle or packet the exact ingredients it contains, and should be prosecuted for any deviation which can be shown to be detrimental to the health of persons using the remedy, or designed to perpetrate upon them a commercial fraud. Further, the Federal Government, or local boards of health, or both, should institute a division for the inspection of these goods, and for a more careful general inspection of pharmacies, to determine whether all compounders of prescriptions are duly licensed, whether a record is kept of all poisons sold, and whether the drugs there offered to the public are pure and not substituted. To start a work of this kind will mean a fight all along the line. The manufacturers of nostrums and adulterated drugs are a very wealthy and powerful class in the community, and they will oppose all remedial legislation to the uttermost. The only thing they cannot stand against is aroused public opinion; and the sanitary officer must see that an intelligent public opinion on this important question shall be created.

Any discussion of the present problems of the sanitarian, however brief and superficial, would be incomplete without some mention of the auxiliary forces at work. Chief of these is the wide and growing public interest in sanitary problems and the evident desire of municipal and village communities everywhere to learn and apply the most rational and effective methods to their particular circumstances and situation. When we recall that men still in the prime of life saw the beginnings of municipal sanitation in the United States, we must realize the great progress that has been made.

It is not conceivable that we shall stop with this degree of attainment. All the great sanitary questions, the prevention of disease and nuisance, the promotion of municipal cleanliness, the disposal of sewage, the utilization of wastes, and a score of other problems which might be mentioned, are still in their infancy, and the handling of them fifty years hence will make our present-day methods appear almost prehistoric. In all this progress, the physician, the bacteriologist, the chemist, and the sanitary engineer will combine their efforts, and the public opinion will support and aid them.

Such a body of public opinion is now being educated in our schools, where the physician, the nurse, and the sanitary inspector are object-lessons in municipal hygiene; in the literature of the day, which is giving especial attention to sanitation in its broadest sense; and, not least, in the numberless voluntary associations in which public-spirited citizens, prominently the women, are striving to correct municipal abuses and aid the sanitary authorities in estabishing a higher standard of public health. With such duties and such aids, continued progress is imperative and sure.

SHORT PAPERS

Dr. Arthur R. Reynolds, Commissioner of Health, City of Chicago, presented a paper containing a plea for twelve-hour milk, in which was discussed the fact that in all state laws and city ordinances not a word is contained as to the age of the milk which is sold.

Dr. J. N. Hurty, Secretary of the State Board of Health of Indiana, presented a paper to this Section on "Dust," and its promotion of infectious diseases.

SECTION B—PREVENTIVE MEDICINE

SECTION B — PREVENTIVE MEDICINE

(*Hall* 13, *September* 21, 3 *p. m.*)

CHAIRMAN: DR. JOSEPH M. MATHEWS, President of the State Board of Health, Louisville, Kentucky.
SPEAKER: PROFESSOR RONALD ROSS, F. R. S., School of Tropical Medicine, University College, Liverpool.
SECRETARY: DR. J. N. HURTY, Indianapolis.

THE LOGICAL BASIS OF THE SANITARY POLICY OF MOSQUITO-REDUCTION

BY RONALD ROSS

[**Ronald Ross,** Professor of Tropical Medicine, University of Liverpool. **b.** May 13, 1857, Almora, India. D.Sc. Trinity College, Dublin, 1904. Post-graduate, Bacteriology, under Klein, London, 1889; Diploma, Public Health, United Colleges, London, 1888; Surgeon, afterwards Major, Indian Medical Service, retired since 1899. Member of the Royal College of Surgeons, England; Fellow of the Royal Society, London; Companion of the Order of the Bath; Fellow of the Royal College of Surgeons; Nobel Medical Prize. **Author of** works and papers on malarial and tropical diseases; and *Algebra of Space* (Geometry).]

THE great science of preventive medicine is often called upon to consider new policies of public sanitation, which, whether they ultimately prove successful or not, are always of profound interest and importance to mankind. Quite recently a new measure of this kind has been proposed, which in the opinion of many promises to rank with house-sanitation and preventive inoculation as a means of saving human life on a large scale. Unfortunately, its value has not yet been clearly demonstrated — with the result that it is not being employed as largely as some of us hoped would be the case. I feel, therefore, that I cannot better acknowledge the honor you have done me in inviting me to address you to-day than by attempting to discuss this important theme — in the hope that the discussion may prove profitable to the cause of public health. The new sanitary policy to which I refer is that which aims at the reduction of disease-bearing insects, especially those which are the disseminating agents of malaria, yellow fever, and filariasis.

I presume that it is scarcely necessary to discuss the evidence which has established the connection between various insects and arthropods and many diseases of man and of animals. The fact that the pathogenetic parasites which produce those great scourges of the tropics just mentioned are carried by gnats is now too well known to require reiteration. It is necessary only to remind you that the gnat acts as an intermediary, becoming infected when biting infected persons and, some weeks later, infecting healthy persons in its turn — the parasite passing alternately from insect to man. The hypothesis that the infection in these diseases may be produced in any other manner than by the bite of gnats has not been justified by any recorded experiments or by any substantial arguments; and we may, therefore, assume for the present that if we could exterminate the intermediary agents, the gnats, in a locality, we could also exterminate there the diseases referred to. But here we enter upon ground which in the opinion of many is much less secure. While some believe in the possibility of reducing gnats in given localities and consider that the point has been proved by experiment, others are much more skeptical and hold that the experiments were not sound. This state of uncertainty naturally causes much hesitation in the adoption of measures against gnats, and, therefore, possibly a continued loss of life by the diseases occasioned by them; and I, therefore, propose to sift the matter as carefully as time will allow.

In the first place, we should note that experiments made in this connection have not been very satisfactory, owing to the fact that no accurate method has yet been found for estimating the number of gnats in any locality. We can express our personal impressions as to their numbers being small or large; but I am aware of no criterion by which we can express those numbers in actual figures. We cannot anywhere state the exact number of mosquitoes to the square mile or yard, and we cannot, therefore, accurately gauge any local decrease which may have resulted from operations against them. A method of doing this may be invented in the future; but for the present we must employ another means for resolving the problem — one which has given such great results in physics — namely, strict logical deduction from ascertained premises.

As another preliminary we should note that mosquito-reduction is only part of a larger subject, namely, that of the local reduction of any living organisms. Unlike particles of matter (so far as we know them) the living unit cannot progress through space and time for more than a limited distance. The diffusion of living units must, therefore, be circumscribed — a number of them liberated at a given point will never be able to pass beyond a certain distance from that point; and the laws governing this diffusion must be the same for all organisms. The motile animal is capable of propelling itself for a time in any direction; but even the immotile plant calls in the agency of the winds and waters for the dissemination of its seeds. The extent of this migration, whether of the motile or the immotile organism, must to a large degree be capable of determination by proper analysis; and the logical position of the question of local reduction depends upon this analysis.

The life of gnats, like that of other animals, is governed by fixed laws. Propagation can never exceed, nor mortality fall below, certain rates. Local conditions may be favorable either to the birth-rate or to the death-rate; and the local population must depend upon the food-supply. Diseases, predatory animals, unfavorable conditions, and accidents depress the density of population; and in fact local reduction, that is, artificial depression of the density of population, practically resolves itself into (*a*) direct destruction and (*b*) artificial creation of unfavorable conditions.

Let us now endeavor to obtain a perfectly clear picture of the problem before us by imagining an ideal case. Suppose that we have to deal with a country of indefinite extent, every point of which is equally favorable to the propagation of gnats (or of any other animal); and suppose that every point of it is equally attractive to them as regards food-supply; and that there is nothing — such for instance as steady winds or local enemies — which tends to drive them into certain parts of the country. Then the density of the gnat population will be uniform all over the country. Of course, such a state of things does not actually exist in nature; but we shall nevertheless find it useful to consider it as if it does exist, and shall afterwards easily determine the variations from this ideal condition due to definite causes. Let us next select a circumscribed area within this country, and suppose that operations against the insects are undertaken inside it, but not outside it. The question before us is the following: How far will these operations affect the mosquito-density within the area and immediately around it?

Now the operations may belong to two categories — those aimed at killing the insects within the area, and those aimed at checking their propagation. The first can never be completely successful; it is in fact impossible to kill every adult winged gnat within any area. But it is generally possible to destroy at least a large proportion of their larvae, which, it is scarcely necessary to remind you, must live for at least a week in suitable waters, and which may easily be killed by larvacides, or by emptying out the waters, or by other means. This method of checking propagation consists, in the case of these insects, of draining away, filling up, poisoning, or emptying out the waters in which they breed. Obviously the ultimate effect is the same if we drain away a breeding-pool or if we persistently destroy the larvae found in it; though in the first case the work is more or less permanent, and in the second demands constant repetition. If we drain a breeding-area we tend to produce the same effect at the end of a year as if we had destroyed as many gnats as otherwise that area would have produced during that period. Thus, though we cannot kill all mosquitoes within an area, even during a short period, we can always arrest their propagation there for as long as we please, provided that we can obliterate all their breeding-waters or persistently destroy all their larvae — which we may assume can generally be done for an adequate expenditure. We must, therefore, ask what will be the exact effect of completely arresting propagation within a given area under the assumed conditions?

The first obvious point is that the operation must result in a decrease of mosquitoes. If we kill a single gnat there must be one gnat in the world less than before. If we kill a thousand every day there must be so many thousands less at the end of a given period; and the arrest of propagation over any area, however small, must be equivalent to the destruction of a certain number of the insects. But this does not help us much. It may be suggested that, after the arrest of propagation over even a considerable area, the diminution of mosquitoes within the area remains inappreciable. What is the law governing the percentage of diminution in the mosquito density due to arrest of propagation within an area?

The number of gnats (or any animal) within an area must always be a function of four variables, the birth-rate and death-rate within the area, and the immigration and emigration into and out of it. If we could surround the area by an immense mosquito-bar, the insects within it (after the death of old immigrants) would consist entirely of native insects; on the other hand, if we arrest propagation, the gnat population must hereafter consist entirely of immigrants. The question, therefore, resolves itself into this one: What is — what must be — the ratio of immigrants to natives within any area? What factors determine that ratio?

Ceteris paribus, one factor must be the size of the area. If the area be a small one, say of ten yards radius, suppression of propagation will do little good, because the proportion of mosquitoes bred there will be very small (under our assumed conditions) compared with those which are bred in the large surrounding tracts of country, and which will have no difficulty in traversing so small a distance as ten yards. But if we completely suppress propagation over an area of ten miles radius, the case must be very different — every gnat reaching the centre must now traverse ten miles to do so. And if we increase the radius of the no-propagation area still further, we must finally arrive at a state of affairs when no mosquitoes at all can reach the centre, and when, therefore, that centre must be absolutely free from them. In other words, we can reduce the mosquito-density at any point by arresting propagation over a sufficient radius around that point.

But we now enter upon more difficult ground. How large must that radius be in order to render the centre entirely mosquito-free? Still further, what will be the proportion of mosquito-reduction depending upon a given radius of anti-propagation operations? What will be that proportion, either at the centre of operations, or at any point within or without the circumference of operations? The answer depends upon the distance which a mosquito can traverse, not during a single flight, but during its whole life; and also upon certain laws of probability, which must govern its wanderings to and fro upon the face of the earth. Let me endeavor to indicate how this problem, which is essentially a mathematical one of considerable interest, can be solved.

Suppose that a mosquito is born at a given point, and that during its life it wanders about, to and fro, to left or to right, where it wills, in search of food, or of mating, over a country which is uniformly attractive and favorable to it. After a time it will die. What are the probabilities that its dead body will be found at a given distance from its birthplace? That is really the problem which governs the whole of this great subject of the prophylaxis of malaria. It is a problem which applies to any living unit. We may word it otherwise, thus — suppose a box containing a million gnats were to be opened in the centre of a large plain, and that the insects were allowed to wander freely in all directions — how many of them would be found after death at a given distance from the place where the box was opened? Or we may suppose without modifying the nature of the problem that the insects emanate, not from a box, but from a single breeding-pool.

Now what would happen is as follows: We may divide the career of each insect into an arbitrary number of successive periods or stages, say of one minute's duration each. During the first minute most of the insects would fly towards every point of the compass. At the end of the minute a few might fly straight on and a few straight back, while the rest would travel at various angles to the right or left. At the end of the second minute the same thing would occur — most would change their course and a very few might wander straight on (provided that no special attraction exists for them). So also at the end of each stage — the same laws of chance would govern their movements. At last, after their death, it would be found that an extremely small proportion of the insects have moved continuously in one direction, and that the vast majority of them have wandered more or less backward and forward and have died in the vicinity of the box or pool from which they originally came.

The full mathematical analysis determining the question is of some complexity; and I cannot here deal with it in its entirety. But if we consider the lateral movements as tending to neutralize themselves, the problem becomes a simple one, well known in the calculus of probabilities and affording a rough approximation to the truth. If we suppose that the whole average life of the insect contains n stages, and that each insect can traverse an average distance l during one such stage or element of time, then the extreme average distance to which any insect can wander during the whole of its life must be nl. I call this the limit of migration and denote it by L, as it becomes an important constant in the investigation. It will then be found that the numbers of insects which have succeeded in reaching the distances nl, $(n-1)l$, $(n-2)l$, etc., from the centre will vary as twice the number of permutations of $2n$ things taken successively, none, one, two, three at a time, and so on — that is to say, as the successive coefficients of the expansion of 2^{2n} by the binomial theorem. Suppose, for convenience, that the whole number of gnats escaping from the box is 2^{2n} — a number which can be made as large as we please by taking n large enough and l small enough — then the probabilities are that the number of them which succeed in reaching the limit of migration is only 2; the number of those which succeed in reaching a distance one short stage of this, namely, $(n-1)l$, is $2.2n$; of those which reach a stage one shorter still is

$$2\frac{2n(2n-1)}{2'}$$

and so on. Hence the whole number of gnats will be found arranged as follows:

Distance from centre	nl	$(n-1)l$	$(n-2)l$	$(n-3)l$	etc. total.
Number of gnats	$2+$	$4n+$	$2\frac{2n(2n-1)}{2'}+$	$2\frac{2n(2n-1)(2n-2)}{3'}+$	etc. $=2^{2n}$.

It therefore, follows from the known values of the binomial coefficients that if we divide the whole number of gnats into groups according to the distance at which their bodies are found from the box, the probabilities are that the largest group will be found at the first stage, that is, close to the box, and that the successive groups, as we proceed further and further from the box, will become smaller and smaller, until only a very few occur at the extreme distance, the possible limit of migration. And the same reasoning will apply to a breeding-pool or vessel of water. That is, the insects coming from such a source will tend to remain in its immediate vicinity, provided that the whole surrounding area is uniformly attractive to them.

The following diagram will, I hope, make the reasoning quite clear.

We suppose that 1024 mosquitoes have escaped during a given period from the central breeding-pool P, and we divide their subsequent life into 5 stages — the numbers 1024 and 5 being selected merely for illustration. Rings are drawn around the central pool in order to mark the distance to which the insects may possibly wander up to the end of each stage; and the continuous line shows the course followed by one which has wandered straight onward all its life and has died at the extreme limit to which an insect of its species can generally go, namely, the outermost circle, *L*. On the other hand, the dotted line shows a course which is likely to be followed by the largest number of the 1024 insects liberated from the pool — that is to say, a quite irregular to-and-fro course, generally terminating somewhere near the point of origin. The

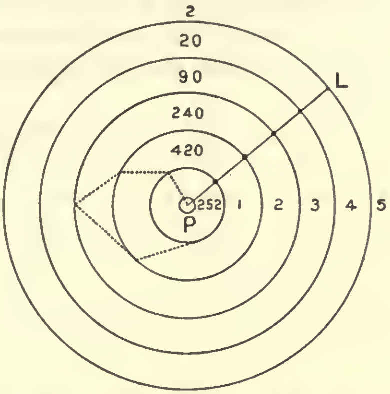

DIAGRAM I. The chance-distribution of mosquitoes. *P*, central breeding-pool. *L*, limit of migration. The numbers denote the proportions of 1024 mosquitoes starting from *P* which die at the distances 1, 2, 3, 4, 5, respectively. The continuous line denotes a continuous migration always in one direction; the dotted line, the usual erratic course.

numbers placed on each ring show the number of mosquitoes calculated from the binomial coefficients when $n=5$, which are likely to reach as far as that ring at the time of their death. Thus only 2 out of the 1024 mosquitoes are ever likely to reach the extreme limit; while, on the other hand, no less than 912, or 89 per cent, are likely to die somewhere within the second ring around the centre.

The same reasoning will apply whatever may be the number of mosquitoes liberated from the pool, or the number of stages into which we arbitrarily divide their subsequent life. Suppose, for example, that 1,048,576 mosquitoes escape from the pool and that we divide their life into 10 stages. Then only 2 of all these insects are ever likely to reach the extreme limit of the outermost circle; only 40 will die at the next circle; only 190 at the next; and so on — the large majority perishing within the circles comparatively close to the point of origin.

This fact should be clearly grasped. The law here enunciated may, perhaps, be called *the centripetal law of random wandering*. It ordains that when living units wander from a given point *guided only by chance*, they will always tend to revert to that point. The principle which governs their to-and-fro movements is that which governs the drawing of black and red cards from a shuffled pack. The chances against our drawing all the twenty-six black cards from such a pack without a single red card amongst them are enormous, as are the chances against a mosquito, guided only by chance, always wandering on in one direction. On the other hand, just as we shall generally draw black and red cards alternately from the pack, or nearly so, so will the random movements of the living unit tend to be alternately backward and forward — tend, in fact, to keep it near the spot whence it started. As there is no particular reason why it should move in one direction more than another, it will generally end by remaining near where it was.

But it will now be objected that the movements of mosquitoes are not guided only by chance, but by the search for food. To study this point, take the diagram just given, place a number of pencil-dots upon it at random, and suppose that each pencil-dot denotes a place where the insects can obtain food — suppose, for example, that the breeding-pool lies in the centre of a large city and that the pencil-dots are houses around it. Consideration will show that the centripetal law must still hold good, because there is no reason why the insects should attack one house more than another. There is no reason why a mosquito which has flown straight from the pool to the nearest house should next fly to another house in a straight line away from the pool, rather than back again, or to the right or left. The same law of chance will continue to exert the same influence, and the insects will always tend to persecute most those houses which lie in the immediate vicinity of their breeding-pool. Even when there are many pools scattered about among the houses, there is no reason why, after feeding, the mosquitoes will go to one rather than to another; and the result must be that in general they will tend to remain where they were.

Self-evident as this argument may now appear, it is not understood by many who write on the subject and who seem to think that mosquitoes radiate from a centre and shoot forever onward into all parts of the country as rays of light do. Accepting this fallacy without question, they argue that it is useless to drain local breeding-pools because of the influx of mosquitoes from without. Such an influx certainly always exists; but I shall now endeavor to show that it cannot generally compensate for local destruction.

Let us consider a tract of country over which numbers of mosquito breeding-pools are scattered, with houses and other feeding-places lying among them. Suppose we draw a straight line across this country and drain away all the pools to the right of it, leaving all those to the left of it intact. Then all the insects on the left of the line must be natives of that part; and all those on the right of it must be immigrants which have crossed over the line from the left. How many mosquitoes will there now be on the right side, compared with those on the left side? The following diagram will enable us to consider this question more conveniently.

First, examine the state of affairs before the drainage was effected. We may suppose that mosquitoes were then breeding fairly uniformly over the whole country, and that their density was much the same on both sides of the line. A certain amount of migration

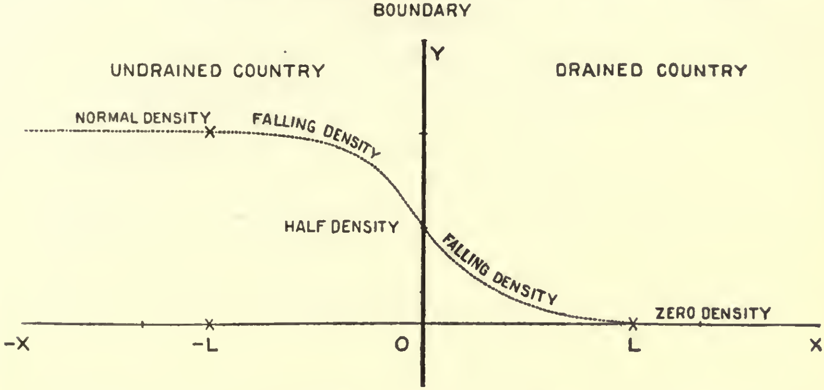

DIAGRAM II. Curve of falling mosquito-density due to drainage on right boundary. L and $-L$ are the limit of migration on either side of the boundary.

across the line, both from right to left and from left to right, must always have been going on; and since the density was equal on both sides, this migration must also have been *equal and opposite* — that is, as many emigrants must have been constantly passing from right to left as from left to right. Now, after the drainage has been effected the following changes occur. The insects breed as before on the left of the line, and some continue as before to cross over it into the drained country; but, in the latter, on the right of the line, propagation is entirely checked and, moreover, the migration from it to the left of the line, which used to exist, now ceases. Hence not only must there be a decrease of mosquito-density on the right of the line, due to the local cessation of breeding, but also a decrease on the left of the line, due to the cessation of the migration from the right which formerly took place — that is to say, the drainage has affected the mosquito-density not only up to the line of demarkation, but beyond it. And moreover, since the migration was formerly equal from both sides of the line, it follows that now, after the drainage, the loss on the left side of the line due to the cessation of immigration from the right is exactly equal to the gain on the right due to the continuance of the immigration from the left. That is to say, the mosquitoes gained by immigration into the drained country must be exactly lost by the undrained country. This fact can be seen to be obviously true if we imagine an immense mosquito-bar put up along the line of demarkation so as to check all migration across it, when, of course, the mosquito-density would remain as at first on the left, and would become absolute zero on the right: then on removing the mosquito-bar an overflow would commence from left to right, which would increase the density on the right by exactly as much as it would reduce the density on the left.

The dotted line on the diagram indicates the effect on the mosquito-density which must be produced by the drainage. If L is the possible limit of migration of mosquitoes (it may be one mile or a hundred, for all we know), the effect of the drainage will first begin to be felt at that distance to the left of the boundary-line. From this point the density will begin to fall gradually until the boundary is reached, when it must be *exactly one half the original density.* This follows because of the equivalence of the emigration and immigration on the two sides. Next, as we proceed from the boundary into the drained country, the density continues to fall, until at a distance L on the right of the line, it becomes zero, the country now becoming entirely free of mosquitoes because they can no longer penetrate so far from the undrained country.

In the diagram the line giving the mosquito-density falls very slowly at first, and then, near the boundary, very rapidly, subsequently sinking slowly to zero. The mathematical analysis on which this curve is based is too complex to be given here; but it is not difficult to see that the centripetal law of random migration must determine some such curvature. The mosquitoes which are bred in the pools lying along the boundary-line must remain for the most part in its proximity, only a few finding their way further into the drained country, and only a very few reaching, or nearly reaching, the limit of migration. Though an infinitesimal proportion of them may wander as far as ten, twenty, or more miles into the drained country (and we do not know exactly how far they may not occasionally wander) the vast bulk of the immigrants must remain comparatively close to the boundary. And as, for the reason just given, the mosquito-density on the boundary itself must always be only one half the original density, it follows that it must become very rapidly still less, the further we proceed into the drained country. In fact, the analysis shows that the total number of emigrants must be insignificant when compared with the number of insects which remain behind — that is, when they are not drawn particularly in one direction. We are, therefore, justified in concluding that, as a general rule, the number of immigrants into any area of operations must, for practical purposes, be very small or inappreciable a short distance within the boundary-line. The following diagram probably represents with accuracy the effects of thorough suppression of propagation within a circular area.

At the circle (*a*) and beyond it the mosquito-density will be the normal density which existed before the operations were commenced. At (*b*), the circle bounding the drainage operations, the density will always be about half the normal density. At the circle (*c*) and within it, the density will be small, inappreciable, or zero. The distance from (*a*) to (*b*) may be taken as being the same as that from (*b*) to (*c*);

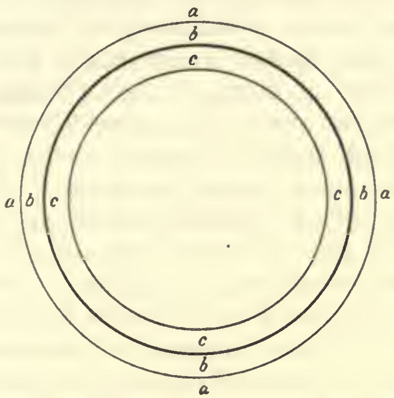

DIAGRAM III. Effect of drainage of a circular area. b = boundary of drained area. Mosquito-density begins to diminish at the circle a; becomes one half at the boundary b; and is small, inappreciable, or zero at the circle c.

and, as the mosquitoes penetrating from (*b*) to (*c*) must be drawn from the zone between (*a*) and (*b*), the *average* result will be the same as if no immigration at all takes place. We do not possess sufficient data to enable us to calculate the actual distance between (*a*), (*b*), and (*c*) — this will depend in a certain measure on the activity of the species of insect concerned and on the existence or absence of special local attractions; but this fact does not discredit the general principles involved.

One case has not yet been considered, namely, that in which there exists only a single feeding-place in the whole tract of country — such, for instance, as a single house or group of houses situated in the midst of deserted swamps. In such a case the insects may be compelled to come from considerable distances — from as far as their senses are capable of guiding them — in search of food; and drainage operations carried on with a view to relieving such a house may, for all we know, have to be extended over miles. But such cases are not of great consequence, because drainage is seldom the appropriate measure for isolated dwellings, which can generally be protected at far less cost by means of gauze screens. Moreover, it is very doubtful whether feeding-places for mosquitoes are ever so solitary as the case assumes. Where there is one dwelling there are generally many, scattered at various distances over the country; and the insects are known to feed on cattle, birds, and other animals. For towns, where anti-mosquito measures are most demanded, our first assumed condition of uniform attractiveness must, as a rule, be the one in force; and in such cases the centripetal law will hold.

The effect of wind requires examination. Theoretically, if the insects are supposed always to remain on the wing, wind blowing on a generating-pool will merely have the effect of drifting the whole brood to a certain extent in one direction without changing the *relative* positions of the insects to each other. The result would be the same as indicated in Diagram I, except that the generating-pool would now be eccentric. If a proportion of the insects take shelter, the circles of Diagram I would become ellipses with the generating-pool as a focus. In such a case the wind, and especially devious winds, would have a distributive tendency; but it must be remembered that if the insects are scattered further apart their numbers at a given point must be reduced. A wind which blows mosquitoes into an area must blow others out of it. The net result of devious winds on a circular drained area would be that the mosquito-density is not so much reduced at the centre, but is reduced to a greater distance outside the boundary circle — so that the average reduction remains the same. With a wind blowing continuously from one direction, the indication would be to extend the drainage further in that direction. Obviously, wind may scatter mosquitoes; but it cannot create them, nor prevent the total average reduction due to anti-propagation measures, as some people seem to think. It is, however, very doubtful whether wind does really drive or scatter mosquitoes to any great degree. In my experience they are extremely tenacious of locality. Thus *Anopheles* were seldom seen on Tower Hill, a low open hill in the middle of Freetown, Sierra Leone, although numerous generating-pools existed a few hundred yards from the top, all around the foot of it, and the winds were often very strong. If a continuous wind can drive mosquitoes before it, then during the southwest monsoon in India they should be driven away from the west coast and massed towards the east coast; but I have never heard that they are at all less numerous on the west coast. I have often seen very numerous mosquitoes on bare coasts exposed to strong sea-breezes, as at Madras. As a rule, they seem to take shelter in the presence of a strong breeze. Instances of their being driven far by winds are frequently quoted, but in my opinion they were more probably bred, in many such cases, in unobserved pools close at hand. The wind-hypothesis is frequently used by municipal officials as an excuse for doing nothing — it is convenient to blame a marsh miles distant for propagating the mosquitoes which are really produced by faulty sanitation in the town itself.

Another and similar statement is often made with all gravity to the effect that mosquitoes are brought into towns in trains, carts, and cabs. So they are; but a moment's reflection will assure us that the number introduced in this manner must always be infinitesimal compared with those that fly in or which are bred in the town itself. Moreover, if vehicles may bring them in they may also take them out.

I will now endeavor to sum up the arguments which I have laid before you — I fear very cursorily and inadequately. First, I suggested that there must be for every living unit a certain distance which that unit may possibly cover if it continues to move all its life, with such capacity for movement as nature has given it, always in the same direction. I called this distance the limit of migration. It should perhaps be called the ideal limit of migration, because scarcely one in many billions of living units is ever likely to reach it — not because the units do not possess the capacity for covering the distance, but because the laws of chance ordain that they shall scarcely ever continue to move always in the same direction. Next I endeavored to show that, owing to the constant changes of direction which must take place in all random migration, the large majority of units must tend to remain in or near the neighborhood where they were born. Thus, though they may really possess the power to wander much further away, right up to the ideal limit, yet actually they always find themselves confined by the impalpable but no less impassable walls of chance within a much more circumscribed area, which we may call the practical limit of migration — that is, a limit beyond which any given percentage of units which we like to select do not generally pass. Lastly, I tried to apply this reasoning to the important particular case of the immigration of mosquitoes into an area in which their propagation has been arrested by drainage and other suitable means. My conclusions are:

(1) The mosquito-density will always be reduced, not only within the area of operations, but to a distance equal to the ideal limit of migration beyond it.

(2) On the boundary of operations the mosquito-density should always be reduced to about one half the normal density.

(3) The curve of density will rise rapidly outside the boundary and will fall rapidly inside it.

(4) As immigration into an area of operations must always be at the expense of the mosquito population immediately outside it, the average density of the whole area affected by the operations must be the same as if no immigration at all has taken place.

(5) As a general rule for practical purposes, if the area of operations be of any considerable size, immigration will not very materially affect the result.

In conclusion, it must be repeated that the whole subject of mosquito-reduction cannot be scientifically examined without mathematical analysis. The subject is really a part of the mathematical theory of migration — a theory which, so far as I know, has not yet been discussed. It is not possible to make satisfactory experiments on the influx, efflux, and varying density of mosquitoes without such an analysis — and one, I may add, far more minute than has been attempted here. The subject has suffered much at the hands of those who have attempted ill-devised experiments without adequate preliminary consideration, and whose opinions or results have seriously impeded the obviously useful and practical sanitary policy referred to. The statement, so frequently made, that local anti-propagation measures must always be useless, owing to immigration from outside, is equivalent to saying that the population of the United States would remain the same, even if the birth rate were to be reduced to zero. In a recent experiment at Mian Mir in India the astounding result was obtained that the mosquito-density was, if anything, increased by the anti-propagation measures — which is equivalent to saying that the population of the United States would be increased by the abolition of the birth-rate. In the mean time, I for one must continue to believe the somewhat self-evident theory that anti-propagation measures must always reduce the mosquito-density — even if the results at Havana, Ismailia, Klang, Port Swettenham, and other places are not accepted as irrefragable experimental proof of it.

SECTION C — PATHOLOGY

SECTION C—PATHOLOGY

(*Hall* 13, *September* 22, 10 *a. m.*)

CHAIRMAN: PROFESSOR SIMON FLEXNER, Director of the Rockefeller Institute.
SPEAKERS: PROFESSOR LUDVIG HEKTOEN, University of Chicago.
PROFESSOR JOHANNES ORTH, University of Berlin.
PROFESSOR SHIBASABURO KITASTO, University of Tokio.
SECRETARY: DR. W. McN. MILLER, University of Missouri.

THE RELATIONS OF PATHOLOGY

BY LUDVIG HEKTOEN

[**Ludvig Hektoen,** Professor and Head of Department of Pathology and Bacteriology, University of Chicago, Director of Memorial Institute for Infectious Diseases. **b.** July 2, 1863, Wisconsin. A.B. Luther College, 1883; A.M. 1902; M.D. College of Physicians and Surgeons, Chicago, 1887; Post-graduate, Upsala, Berlin, and Prague. Pathologist, Cook County Hospital, Chicago, 1890–1904; Physician to Coroner's Office, Cook County, 1890–94. **Co-editor,** *Journal of Infectious Diseases*, etc.]

OSTWALD, the inspiring interpreter of the great principles of science, states that "We have just passed through a period in which all sciences have been isolated, a period of specialization, and we find ourselves in an epoch in which the synthetic factors in science are gaining a constantly increasing significance. . . . Everywhere the individual sciences seek points of contact with one another; everywhere the investigator determines the value which his special results may have in the solving of the general problems. In short, all sciences are tending to be philosophical. Nowhere is this tendency toward fundamental explanation so great as in biology."

Pathology a Division of Biology

Disease is the common lot of all forms of life, high as well as low, animal as well as vegetable, and it is the special province of pathology, the science of disease, to study life in its abnormal forms and activities. Hence pathology is a division of biology, and it is in fact pathological biology, but its relationships as such have not always been so clearly appreciated as they ought to be; in part this may be explained on account of the very special stress placed on its direct application to practical medicine in the service of the art of healing. For this and other reasons pathology in many respects has remained somewhat isolated among biological sciences. The early pathologists took the almost exclusive standpoint of human medicine and for a long time the vast resources of general biology remained practically unused in the study of disease. On the other hand, owing to lack of appreciation of the fact that disease is a phenomenon of life, in other words, owing to the unnatural separation of the biologic study of disease from general biology, the subject of disease has rather repelled the average student of biology, who therefore seems to have neglected to utilize fully the approaches offered by pathology to a better knowledge of the phenomena of life.

In view of the extent to which man has busied himself with the study of all forms of animal life in all accessible parts of the world, is it not rather strange and an evidence of lack of coördination that the occurrence of cancer throughout the whole vertebrate kingdom should have been made out definitely only during the last year? Yet this demonstration by the Cancer Research Fund in London, and the further demonstration that cancer has the same fundamental characters as in man when it occurs in fish, reptile, and bird, renders it extremely improbable that either climate or diet of man has anything to do with the direct causation of cancer, thus putting an end to much needless speculation and materially narrowing the scope of a most important inquiry.

Pathological Processes in Evolution

In some quarters disease has been regarded merely as an expression of inferiority and weakness, and as part at least of the means by which inexorable nature carries out the verdict of extermination. Parasitism for instance has been designated as a weapon to eliminate those who fall below a certain standard. Consideration of the nature of disease from this point of view gives to disease merely a negative evolutional significance, as it would cause no new and better qualities in the descendency. Closer examination would tend to show, however, that processes of disease may have a different significance of a more positive nature in evolution. There are numerous simple as well as complex physiological processes which, when set in motion by abnormal conditions, appear to be of advantage not only to the individual but also to the species. As examples of adaptive processes at first sight of more special individual advantage may be mentioned regeneration, hypertrophy, the interesting adaptations to new and strange conditions of which bones and vessels are capable, certain phases of thrombosis, and even atrophy, which has been described as the faculty of an organ to adapt itself to conditions of diminished nutrition, thus circumventing necrosis, a faculty of great advantage when the period of diminished food-supply is only temporary. No one can fail to see much that must be useful and advantageous in the complex reactions to injuries observed in inflammations, the significance of which has been greatly broadened through the well-known comparative study of Metchnikoff. In the case of immunity, natural and acquired, our wonder knows no bounds, so marvelous are the precision and scope of the protective reactions, concerning which so much has been brought to light in recent years and which lend themselves well to comparative studies. In the case of degenerations and tumors it is not possible to recognize any direct or indirect advantage, and certainly no one has yet been able to see malignant tumors in such favorable light. In these instances first mentioned the pathologic reactions have physiologic prototypes; they are adaptations of physiologic processes. Regeneration and growth are taking place constantly in health. Phagocytosis, on which so much stress has been laid in inflammation, is merely an exaggeration of normal nutritive processes in certain cells. At present the production of antitoxins and other anti-bodies is best explained as the result of special adaptations of normal stereo-chemical mechanisms whereby nutrition is carried on. A very noticeable difference between the physiologic and pathologic manifestations of these functions is seen in their imperfections and shortcomings under many of the abnormal conditions. Incomplete regeneration resulting in the formation of scars often has many disadvantages. Inflammations frequently establish conditions in themselves fraught with dangers. The reactions of immunity may not neutralize quickly enough the toxins nor destroy promptly enough the invading organisms. Hence there is abundant scope for the intervention of the physician armed with all the various appliances of his art, some of the most useful of which are the products of artificially produced biologic reactions. But after all the individual organisms must enjoy the best chances for survival and reproduction that suffer least harm because best able to adapt themselves and to protect the life and function of their cells under conditions of disease.

Just as there are variations in the limits of physiologic regulatory mechanisms, so also there are individual differences of degree in the power of adaptive and protective reactions to establish themselves in disease and permit continuance of life. In progressive evolution it naturally must be in the descendants of individuals with the best adaptive and protective powers that an increasing completeness and perfection of such powers will be found. Viewed in this light many processes of disease assume a significance of positive character in biologic evolution, a point of view that would increase the interest in pathology among biologists in general, and thus tend to further its development along broader lines and lead to coördination of knowledge and broad and still broader generalizations as to causes, nature, and processes of disease. At present we may be said to be gathering materials for this broader comparative pathological biology of the future in the same way as the older naturalists gathered materials for the biologist of the present day.

Pathology and Research

At least in certain fields the student of the pure science of disease is primarily interested in the knowledge of disease for its own sake without much thought or immediate care as to any prompt practical use to which such contributions as he may make to this knowledge may be put. It is true here as it is in general that most things are done only on account of the results expected from them in the future, but immediate technical utility is not always the sole guiding principle of the investigator in pathologic domains. The history of pathology shows him that in this science as well as in its synthetic sciences all actual increase in knowledge eventually helps to relieve suffering. Everywhere the most intimate relations may be seen between the progress of medical knowledge and the progress of medical art. Like other sciences pathology furnishes many examples of the rather unexpected importance and the even profound influence of the new observation, the new methods of study, the new point of view that at first seemed to have but limited significance. Indeed some of the fundamental ideas of scientific medicine have arisen in this way. It has been well said that no knowledge of substance or force or life is so remote or minute, but that to-morrow it may become an indispensable need (van Hise). We in America have therefore much reason to rejoice because of the strong movement that is starting in the interest of scholarship and of research in pathology, a movement that of course does not limit its influence merely to the advancement of knowledge, but exercises as well a powerful influence upon the diffusion of knowledge. The man who is so full of enthusiasm for pathology that he will "burn his lamp for its advancement" is likely also to be an inspiring teacher illuminating the older knowledge with the discovery of to-day and placing the new facts in their proper relations to what is already known and to what will be known. Medicine in this country has been so preoccupied with building-up medical education for the training of physicians that comparatively little energy has been available for the upbuilding of medical science itself. Thus pathology in the universities has not been taught until very recently in such a way that graduate students might take it up as a branch to be followed through long stretches of labor. This is regrettable, but in some of our universities pathology is now placed on equal footing with other natural sciences and fully recognized as a proper field for work leading to higher degrees, and this is a much desired progress in a most important direction. The direct interest now taken by many persons in medical research, the institutes and funds their munificence has established, are also having a most profound influence upon the development of pathology in this country. Another mighty current in favor of this development has set in from the scientific work carried on in our various governmental and state institutions.

Pathology and Synthetic Sciences

Let us now attempt to trace briefly the present relations of pathology to cognate sciences with the object of learning, if possible, in which direction the hope lies for greatest progress and to mark out the paths along which our investigators must journey in order to gather the best materials for that wider and larger pathological biology upon which we are still to work. The clearest conception of the rôle that the more important synthetic factors have had and are having upon the development of pathology will be obtained through the historical perspective. In this way, too, it may prove feasible to show how some of the special problems have been solved and to bring into relief the great coördination of useful knowledge exemplified by practical medicine and the influence upon it that various sciences have had and are having through the medium of pathology.

The Anatomical Idea in Medicine

Anatomy was one of the earliest biological sciences to receive cultivation. The first laboratory for the training of students was the anatomical. One cause at least for this, if not the cause, was the downright necessity for physicians to become closely acquainted with the structure as well as the functions of the human body. It is consequently not strange that pathology in the usual modern sense should begin as pathological anatomy, that is with the study of the grosser, evident alterations in structure that result from disease and upon which in turn rest many of the disturbances of function observed in disease. In its earlier stages pathological anatomy busied itself with the accumulation of a store of facts and observations gained almost wholly by the examination of human bodies after death. Morgagni was the first to attempt any generalization from this store of facts and by correlating the anatomical changes observed after death with the disturbances of functions observed as clinical symptoms during life, he was able to draw conclusions of fundamental importance in regard to the seats and causes, at least in certain phases, of disease. This is the first instance of synthesis on a large scale of two biological sciences in the study of pathology, namely the physiological or study of function and the anatomical or study of structure. Morgagni's conception of disease as inseparably connected with structural changes in the organs was designated happily by Virchow as the anatomical idea in medicine, and this idea — the greatest gift of anatomy to medicine — proved of incalculable service in turning the minds of physicians away from speculation to careful, objective study of disease during life as well as after death. We catch an interesting glimpse of Morgagni's own point of view in the following quotation from his writings: "The various steps in progress ought not to be disregarded, for, in difficult research, we derive encouragement from the recollection that although the exertions of an individual may not advance philosophy in any perceptible degree, yet, owing to the power of experiment and the successive influence of opinion, the most obscure and apparently unsuccessful inquirer may prove the first or the connecting link in a series of most valuable discoveries."

The Cell Doctrine

The next advance was the result of Bichat's introduction of minute anatomy and the demonstration that the organs consist of tissues to which the seat of disease now was referred. Before long came the epochal development in botany under the influence of Schleiden of the cell doctrine, which was applied by Schwann to normal animal histology, and by Virchow in 1858 to pathology, the direct outgrowth being the justly celebrated cellular pathology beginning an era during which medicine has made greater progress than in all preceding time.

Physiological and pathological processes were traced to the elementary morphologic constituents of living organisms — the cells. The famous phrase "*omnis cellula e cellula*" completed the liberation of medicine from abstract speculation already begun by Morgagni. "The physician grew from a schoolman into a scientific observer, and the surgeon, who appeared on the scene in livery and without learning, grew from a handicraftsman to be a man of science." Pathology became a natural science. What rich new fields were now open for investigation! A vast amount of material was accumulated from careful clinical and morphologic study of individual cases and the basis thus laid for the construction of general laws and fruitful theories of disease. During the earlier part of this period attention was confined largely to man, but it also was often turned in the direction of animals in the effort to penetrate deeper into morbid processes; the experimental method was used to interpret correctly observations made in the clinic and in the post-mortem room.

Of fundamental importance for all branches of medicine was the resulting organization of the teaching and investigation of pathological anatomy. Following the leadership of Virchow in Berlin pathologico-anatomical institutes or laboratories were rapidly established, and soon recognized as indispensably necessary for teaching, for research, and for direct assistance to medical practice. In the further course of development these laboratories have undergone various modifications and enlargements of scope, principally as the result of the advent of medical microbiology.

With surgery and the rapidly developing surgical specialties pathological anatomy — gross and microscopic — soon assumed permanent relations of fundamental character. The anatomical study of the diseases in question was followed by great progress in treatment, and the exponents of these branches of applied medicine did not remain merely receptive of the work of others, but have themselves prosecuted diligently pathological investigations of great value. Indeed, in certain special branches, especially ophthalmology, otology, and dermatology, the clinicians have long been practically the sole occupants of the field of pathological anatomy of their respective parts of the body. The close study of pathological anatomy — being largely the study of the results of disease — stimulated also to brilliantly accurate diagnosis of certain internal diseases, which unfortunately in some cases was coupled with a disheartening therapeutic pessimism. Said the therapeutic nihilist Skoda: "We can diagnose disease, describe it, and get a grasp of it, but we dare not by any means expect to cure it." That some of the followers of cellular pathology in the narrower, dogmatic sense, believed that the innermost secrets of disease could be reached by morphologic methods, and that functional disturbances always could be adequately explained by morphologic means may now be regarded as an instance of the tendency man frequently shows to approach his problems from the least accessible points. These unfavorable tendencies in pathology led to the following protest by Clark in 1884:

"We are so much concerned with anatomical changes; we have given so much time to their evolutions, differentiations, and relations; we are so much dominated by the idea that in dealing with them we are dealing with disease itself that we have overlooked the fundamental truth that these anatomical changes are but secondary and sometimes the least important expressions or manifestations of states which underlie them. It is to these dynamic states that our thoughts and energies should be turned; they precede, underlie, and originate structural changes; they determine their character, course, and issues; in them is the secret of disease, and if our control of it is ever to become greater and better, it is upon them that our experiments must be made."

Fortunately Clark's warning had been anticipated by development. Virchow himself long before repeatedly emphasized that pathological anatomy cannot deal forever with the product without searching for the cause that led to its production. It seems to me that the following highly remarkable statement in the Prospectus of the first volume of Virchow's *Archiv*, published in 1847, shows that the founder of cellular pathology had a wonderfully clear vision of the rôle pathological anatomy was to play in the evolution of pathological physiology:

"The standpoint we aim to occupy is simply that of natural science. Practical medicine, the applied theoretical, the theoretical-pathological physiology is the ideal we shall strive to reach so far as our powers permit. While we recognize fully the title and the independence of pathological anatomy, and of the clinic, they serve us preëminently as sources of new questions the answers to which fall to the lot of pathological physiology. Inasmuch, however, as these questions to a large extent may be formulated only through painstaking and comprehensive detailed study of manifestations (of disease) in the living, and of the conditions in the dead, we regard the exact growth of anatomical and clinical experiences as the first and most important demand of the present time. From an empiricism of this kind will result gradually the true theory of medicine, pathological physiology!"

Microbiology, Etiology, Comparative Pathology

It was reserved for etiology, the offspring of microbiology, "to lift pathology permanently out of the level of a purely descriptive science, for with the entrance of a dynamic factor, a causal element, under the guise of microörganisms, the experimental era began definitely."

The coming of microbiology, long foreshadowed by ingenious speculations concerning infectious diseases, at once made pathology broader and definitely comparative in its scope, thus widening its relations to general biology on the one hand, and to preventive and curative medicine on the other. It will be recalled that the founders of bacteriology — Pasteur, chemist and biologist, and Koch, physician — both made their appearance in medicine as investigators of animal infections. Infectious diseases constitute a prominent part in the field of pathology, and deeper insight into their nature required simple, easily controllable conditions accessible to experiment and analysis. This became possible by the discovery and study of microörganisms which could be used to set in motion the complex phenomena of disease according to the pleasure of the investigator. In animals the course of a disease may be cut short at any time for the purpose of investigation and better insight obtained into the evolutions of morbid processes. The disease may be studied in all its phases. Hence comparative pathology rapidly became the refuge of the investigator finding his way blocked by the necessary restrictions governing the study of human diseases. The great influence of the comparative method of study of infectious diseases is well shown in the relatively advanced state of our knowledge in regard to those human diseases of this class that are readily communicable to animals as compared with our ignorance in regard to the cause of certain other human diseases which so far as we know are not transferable to animals.

As the secrets of the vast domain of parasitism were revealed, and the teachings of specific etiology and pathogenesis became appreciated, there sprang up in the place of the therapeutic hopelessness inspired by the study of pathological anatomy only, an increasing interest of enormous consequences in preventive measures. This was the natural outcome of the persistent efforts now made to follow the chain of causation so far as it was possible to go; for it early became established that the farther back of the immediate causes of diseases we can come the more easily and economically are they controlled and, reversely, the nearer we approach the period in the evolution of disease characterized by open manifestations the more difficult is disease to overcome. Hence the newer ideas of cleanliness, of surgical asepsis, sanitary science, and preventive medicine, — all are the offspring of the study of microbiology and etiology in a wide sense. Indeed, the great principle of prevention may be applied with perfect success even when the actual cause of the disease remains unknown. The discovery by Walter Reed, for instance, that the cause of yellow fever is conveyed by a certain kind of mosquito makes it possible to prevent this destructive disease with absolute certainty by destroying the mosquito or preventing its bite.

Interaction of Parasite and Host — Bio-chemistry and Immunity.

But the fundamental problems of etiology are not wholly solved by the discovery of the causative agent, however important this step may be; for it remains to explain how normal function and structure are upset by the entrance of this new factor.

Now the study of bacteriology and comparative pathology has permitted a deeper penetration into the nature and mechanism of certain infections. The discovery of bacterial and other toxins, complex, soluble, and diffusible chemical substances, and of their wonderful influence upon the metabolism of cells, opened new and rich fields that under the hands of keen investigators have furnished precious materials for the advancement of medical science along new lines. Henle had anticipated many of our ideas of the interaction of parasite and host, but especially interesting are the teachings of Bretonneau in regard to the specificness of infectious processes, and the words of his pupil, the great Trousseau, have proved themselves of prophetic significance: "There are [in infectious diseases] two factors; one is the morbific germ coming from without, and the other is the economy about to receive it; there is required a special aptitude for the organism to respond to the action of the stimulus . . . when there is no such predisposition the morbific germ perishes." It was necessary to erect the great structure of cellular pathology, and to make brilliant and epochal discoveries in morbific etiology before the suggestions in Trousseau's statement as to the interaction of host and parasite could be expressed in such definite terms, and given such enlargement in scope as in the genial and heuristic side-chain theory of Ehrlich. According to this theory a toxin is poisonous only when it unites chemically with some constituent in the cell of corresponding stereochemical configuration. If the cell does not contain this particular constituent the toxin is harmless; and when these constituents course in the blood as the result of reproductive processes in the cells they are protective — antitoxic — because they unite with the toxin and thus prevent the disastrous union of toxin with cells. In other words, the substance in the body which, when situated in the cells, is a primary essential for the toxic process, becomes a curative agent when it enters the blood-stream (Behring).

Fortunately for the therapy and prevention of diphtheria, tetanus, and a few other essentially toxic infections, these antitoxins may be caused to accumulate in large quantities in the blood of certain animals when artificially immunized by the injection of increasing doses of the corresponding toxin. It was a happy inspiration indeed that led Behring to use the antitoxic serum of immunized animals for curative and prophylactic purposes, thus turning to the common good this innate faculty of the animal organism to develop in so marvelous a manner its own resources.

Supported by numerous experiments among the most imaginative and interesting of modern biologic investigation, Ehrlich's theory has proven a veritable master-key to some of the innermost secrets of toxic and antitoxic action and immunity in general. The theory has been found adaptable to other closely related problems in chemical biology, and its signal usefulness in promoting investigation in this complex field upon broad comparative basis places it among the great theories of science.

Ehrlich's side-chain theory has been applied with great success to the explanation of the formation by cells, and also of the action of the various lytic or solvent substances for animal cells, particularly red corpuscles, as well as for bacteria. The active hemolysins, bacteriolysins, and cytolysins are formed by the union of two distinct bodies, amboceptor and complement, whose properties and affinities are being studied most actively. These substances occur to a considerable extent in the blood of normal animals, and may be induced to develop freely under the stimulation of the injection into animals of large quantities of the cells or bacteria to be acted upon. The fact that hemolytic substances, though of a somewhat different and apparently less complex nature are produced by certain pathogenic bacteria of common occurrence, especially streptococci, has given us a new point of departure for the study of the anemia that develops in streptococcal and other infections. By the aid of Ehrlich's theory it has also proved possible to explain the mode of action of the toxic substances in certain venoms, and in this particular field highly valuable facts have been established by the work of Flexner and Noguchi and of Kyes. In certain phases the subject has been simplified by the work of Kyes, who succeeded in showing that a definite chemical substance, namely, lecithin, may act as a complement to amboceptors in venoms, with which it unites as a crystallizable "lecithid."

The extraordinary complexity of the chemical bodies produced by cellular activity is further illustrated by the group of substances known as agglutinins which have the interesting property of drawing animal as well as bacterial cells together into clumps. Agglutinins may be produced by bacteria as well as by animals. It is more than likely that certain forms of thrombosis met with in infections are caused by agglutination of corpuscles, a form of thrombosis which has been designated as agglutinative. Experimentally such thrombi are produced with ease by the injection of various agglutinating substances. In animals as well as in man certain infections, *e. g.*, with typhoid bacillus, are associated with the development of agglutinins having a specific effect upon the bacterium causing the infection. Such agglutinins are being used everywhere for two purposes, (*a*) to determine the nature of the infection for purposes of clinical diagnosis (as in the agglutination test for typhoid introduced as a clinical measure by Grünbaum) and (*b*) to identify certain bacteria and establish their relations to the infection.

Another interesting group of substances of the same general class is formed by the coagulins which have the power of causing certain changes in colloidal albuminous solutions.

Furthermore it has been found that the serum of an animal treated with a proteid forms precipitates with that one proteid, a property that within certain limits appears to be specific. This has led to the use of specially prepared precipitating serums for the diagnosis of different proteids, *e. g.*, the detection of human blood for medicolegal purposes, and for the study of the genetic relationships of certain animals, a study that in the hands of Nuttall has given results of general chemico-biological interest from an evolutional point of view.

Reviewing these remarkable developments one is profoundly impressed with the fact that at the same time as they constitute a most important widening-out of biochemical science they have added greatly indeed to the permanent resources of practical medicine, emphasizing again in the clearest way the everlasting identity of the scientific and the practical. Let no one, at least in the medical profession, ever doubt the practical value of the knowledge that ripens on the tree of science! These developments also demonstrate that there are other modes of progress toward knowledge of cellular activity and biological mechanisms under pathological as well as normal conditions than the purely morphologic highway which hitherto had been followed with great persistence in pathology.

Here we are dealing with chemical substances and chemical and physical processes which ultimately will be interpreted in terms of chemistry and physics. Already Arrhenius and Madsen have attempted to show that the laws of mass-action and chemical equilibrium govern the reactions between toxin and antitoxin, an attempt that has precipitated a sharp controversy with the Ehrlich school which cannot but powerfully stimulate continued work in this field. Recently we have learned too that many salts in ionizable solutions and also more complex substances combine in such a way with the complements in normal and immune serums as to hinder the union of complement and amboceptor necessary for lytic action. Perchance it is in this direction that we may look for some insight into the changes in physiological mechanisms that permit various organisms to enter and set up disease.

It seems that in the chemistry of immunity we soon may expect most interesting developments. The fact that lecithin may act as complement, that it forms a crystallizable "lecithid" by union with the hemolytic amboceptor of snake-venom, and further, the evidence now at hand that colloidal silicic acid may play the part of amboceptor, warrant the hope that before long complete analysis, and perhaps even synthesis, of lysins may become possible.

The Synthesis of Different Methods in Scientific and Practical Medicine

In the majority of cases we owe our first knowledge of the existence of distinct diseases to clinical observation. By keen study physicians were able to distinguish even between more or less similar pictures, but the clinical picture has not always proved adequate for the determination of disease-entities. The clinical manifestations of certain diseases are so much alike that differentiation finally was accomplished as the result largely of the study of the more or less characteristic structural changes in the tissues of the body. In some cases differentiation could be made only after the discovery of the specific causative organism. This was the case with diphtheria. The clinical manifestations and the local anatomical changes in the throat caused by the bacillus of diphtheria may be reproduced in streptococcal and other infections. Now it is self-evident that real penetration into the nature of a disease demands its complete separation from other, in certian respects more or less similar, diseases. In the case of diphtheria, for instance, complete etiologic differentiation was essential in order that the real value of diphtheria antitoxin might be learned. It may be mentioned, too, that it required the discovery by Koch of the same bacillus in practically all forms of human tuberculosis before the doctrine of the dual nature of this disease, at one time advocated by Virchow on anatomic grounds, received its final overthrow.

In various local inflammatory diseases such as pleuritis, pericarditis, peritonitis, meningitis, and in many so-called septic conditions, *i. e.*, local infections with general intoxication but with or without bacteremia, the same clinical manifestations and anatomical changes may be produced by different organisms. The diseases being different etiologically are consequently also in all likelihood different chemically in spite of their clinical and anatomical similarities, and for these reasons deeper penetration into their nature as well as progress in direct treatment will depend largely on study of the organisms concerned and of the products of their activities. Clearly an essential step in this direction is the differentiation of the diseases on etiologic grounds. Other examples of analogous nature could easily be cited.

Now, practically every disease the nature of which we in some degree understand may be cited in illustration of the close synthesis of clinical observation (clinical pathological physiology), pathological morphology, etiology, and microbiology, experimental and comparative methods, and especially more recently of chemistry in the development of our knowledge of disease. To the fullest extent this is true of certain infectious diseases. Starting with normal physiology and anatomy, these have become the principal methods by which material is accumulated for that pathological physiology which Virchow put as the chief end of medical investigation. And it is along this road too that the medical student passes to reach membership in the medical profession; for here also "ontogeny repeats phylogeny." Finally these are also the very methods of procedure employed by the true physician in solving the problems of diagnosis and so of treatment presented by the individual patient no matter to what specialty the case may be referred in consequence of the great differentiation of medical art with which we are familiar.

Practical medicine is availing itself more and more of the methods of scientific medicine. The laboratory is entering into closer and closer relations with the clinic. For the purpose of facilitating investigation as well as treatment it has been found advantageous to include various laboratories in the clinic, and the use of laboratory methods has extended to all departments of medical practice where their field of usefulness is constantly enlarging. How these methods may be made most easily available for the practitioner has now become a problem of real urgency. Pathology is consequently a great force in the interests of integration as opposed to differentiation in medicine; for pathology gathers under her wings all the specialties which differ not as to methods but only in the matter of the fields investigated.

Whatever the rôle of pure morphology in the investigations of fundamental biological problems — and it does not seem likely that it will lose greatly in significance in this respect so long as biologists regard the peculiar complexus of physical conditions called structure as absolutely essential to life — it always will maintain relations of fundamental importance in medicine. Medical and surgical diagnosis rests to a large extent upon the recognition of the nature and cause of gross changes in structure and their consequences on function. To the surgeon pathological anatomy is a guide whose minutest direction he must obey. Exact clinical observation controlled so much as ever possible by anatomical examination will continue, as emphasized always by Chr. Fenger, the mainstay of medical progress in every locality. The value of microscopic anatomy in the study of diseases of the blood, in the differentiation of new growths, and in inflammatory products needs only mention. Many of the methods of microbiology are essentially morphologic. The established classification of bacteria is based on morphology, and the studies of the relations of microörganisms to the cells of the body — often a matter of great importance — requires morphologic methods.

I believe there is no room for the opinion one occasionally hears expressed to the effect that the value of the usual methods of morphology and microbiology in scientific pathologic investigation has been exhausted. Of course the field cannot be said to be so large as at one time, but there are still problems enough demanding the use of these very methods, refinements and improvements in which are constantly increasing their usefulness. Unquestionably advances in our knowledge of functional localization and in the tracing of conduction paths in the central nervous system of man will continue to depend in the main on the careful study of anatomical lesions and their functional and structural consequences. Blastomycosis and paratyphoid fever are brilliant examples of "new diseases" recently established as the result of purely morphologic and microbiologic methods of study in fields long diligently explored. In trypanosomiasis and piroplasmosis of man and of animals we have other examples of interesting diseases for the recent knowledge of the existence of which as etiologic entities we are indebted chiefly to clinical observation and morphologic studies of the blood. These facts indicate that microbic etiology may yet be forced to yield up hitherto carefully guarded secrets to more or less familiar methods of new modifications thereof.

Great interest has been awakened in the recent determined effort by Councilman and his associates to solve by these methods the etiology of variola, the final proof of the success or failure of which must be left to more discriminating forms of microbiologic research.

In pathology purely morphologic methods have surely as great an importance in establishing etiologic relationships and as a means of orientation in various forms of investigation as they have in unraveling the intricate connection between structure and function. Progress in the domains of microscopic pathological morphology and progress in normal morphology will always be mutually helpful because pathological cellular changes — necrosis, necrobiosis, degenerations, and proliferations — are probably largely identical with normal cytomorphosis, being abnormal only as to time and place. A recent morphological observation of great interest is that by Bashford and Murray of a process of conjugation in cancer cells. These observers found in cancer cells nuclear changes similar to those by which sexual cells are prepared for fertilization and also fusion of nuclei equivalent to the process of fertilization known as conjugation. This discovery (if confirmed) will help to turn the search for the causative factor in cancer directly to the very processes in the cells themselves, a direction indicated already by the singular fact that cancer always "breeds true," and that it is transplantable only within the species in which it originates, and that it behaves as an independent organism. Undoubtedly the newer methods of study of micro-chemical reactions in normal cytology will prove valuable also in pathological cytology. Perchance this synthesis of morphological and chemical methods in time may give us some insight into the normal relations and time-sequence of chemical reactions in biological processes, normal as well as abnormal.

It proved to be an auspicious day both for chemistry and medicine when Pasteur conceived his biological theory of alcoholic fermentation. Ludwig's prophecy of forty years ago that chemical physiology would largely prove a study of catalytic reactions has come true, and the cell is now no longer considered as a simple structure, but rather as a most complicated machine, the working of which for the most part is dependent on enzymes. Into the finer details of the manner in which these mechanisms may be disturbed under abnormal conditions we as yet have hardly been permitted to penetrate, but the extensive recent researches dealing with the nature and mode of action of ferments in diverse physiological activities have awakened a lively interest in fermentations in pathological processes which augurs well for the future.

Among the many intracellular ferments those causing self-digestion or autolysis of cells are thought to play an active and essential rôle in the removal of dead material, such as necrotic tissue in infractions and inflammatory exudates. Some idea of the fermentative activities in autolysis may be obtained from its action in pneumonia. In a few days autolysis may so alter a mass of exudate weighing several hundred grams that it is readily removed from the lungs by absorption and expectoration.

The biochemical mechanisms of normal and pathological pigment formation have now been shown to depend on the action of oxidative ferments.

Cohnheim's demonstration that two enzymes, one coming from the pancreas and the other from the muscles, are necessary for the oxidation of sugar, appears to be a long step toward putting the pathogenesis of diabetes in an entirely new light. While these and other oxidizing ferments are the products of cellular activity, it at once suggests itself that they need not be the products of the cells of the same body which is later to use them. It has been suggested that they may be introduced as needed much as antitoxins now are introduced (Long).

The results of the work of Croft Hill and of Kastle and Loewenhardt on the reversibility of ferment action have been eagerly grasped by pathologists and made to throw new light on the problems of fat absorption and translocation. Indeed, the newer chemical methods of study are changing completely our older ideas about fatty changes in the cells, ideas that were based almost wholly upon morphological appearances. Great progress has been made also in other respects in recent years from the application of the methods of physiological chemistry to pathological problems, but I must refrain from going into further details. As a result the field of pure chemistry as an aid to medical diagnosis is enlarging, not merely as regards various analytical procedures for the testing of fluids and other substances, but the newer methods of physical chemistry such as testing the solution content by electrical conductivity and cryoscopy have been found useful in order to obtain information of help in reaching a correct diagnosis or a better understanding of the nature of the functional disturbance.

As indicated in the foregoing we are now at the beginning of an era of the application of newer physical and chemical methods to many problems in medicine, problems that at one time were regarded as approachable only by so-called biological methods, and the number of problems that lend themselves promisingly to this form of treatment seems to be constantly increasing. I have referred already to their use in the study of chemical problems in immunity. The many fundamental problems connected with the constancy of osmotic pressure in the fluids of the body; the great influence of osmotic disturbances in the production of edema; the interesting relations of ions to proteins; the physico-chemical properties of ions of various salts in relation to pharmacological action — these are some of the new questions that are being actively studied with results in many cases of far-reaching importance.

In many of its phases this departure is the outcome of the application by Loeb and others of general chemistry to biological study the results of which we have followed with increasing wonder as they have shown us the extent to which certain life phenomena can be controlled unequivocally by chemical and physical means. Many of the manifestations of life are physical in character, but biologists are agreed that the source of energy in life phenomena is chemical, and that general chemistry therefore must form the foundation of biology. From this it follows directly that the deeper, fundamental explanation of the mechanisms of pathological processes also requires chemical and physical methods. Henceforth chemistry will play an increasingly important rôle in the efforts to reduce the phenomena of pathological biology to simpler laws. We thus find again that sharp lines of demarkation cannot be drawn between normal and pathological biology; for progress in one naturally exercises determining influence on progress in the other, and in both development is in the direction of synthesis with physics and chemistry.

Medicine has been called the mother of sciences, and not without reason. She gave to physics Galileo, Mayer, Helmholtz; to geology Steno; to botany Linnaeus; to chemistry Black, Berzelius, Liebig; to biology Aristoteler, Lamarck, and Huxley; but as pointed out by Sir Michael Foster, her children are ever coming back to help her. In medicine as a science and as an art many sciences converge — physical, chemical, and biological methods join hands for the advancement of knowledge and the relief of suffering.

WORKS OF REFERENCE

Of the various articles from which I have drawn freely in preparing this address I would mention the following especially:

Barker, L. F., The Unveiling of the Cell, Jour. Am. Med. Assoc. xxxvii, 577–82, 1902.

Chiari, H., Die Pathologische Anatomie in 19. Jahrhundert und ihre Einfluss auf die Aüssere Medicin. Verh. d. Naturforscher u. Aerzte, 1900, Allg. Theil.

Councilman, W. T., The Relations of Pathology to Medicine, cxxxviii, 557, 1898.

Flexner, S., An Aspect of Modern Pathology, Science, 1903.

Harbitz, Fr., Hovedträk af den Patologiske Anatomis Udvikling. Norsk Magazin for Lägevidenskaben, 1900.

Loeb, J., The Limitations of Biological Research, University of California Publications, Physiology, i, 33-37, 1903.

Long, J. H., The Relations of Chemistry to Modern Medicine, Science, xx, 1-14, 1904.

Ostwald, W., The Relations of Biology and the Neighboring Sciences, University of California Publications, Physiology, i, 11-31, 1903.

Salomonsen, C. J., General Pathology as a University Subject, Festskrift ved Indvielsen af Statens Serum Institut, Copenhagen, 1902.

Smith, Th., Comparative Pathology: Its Relation to Biology and Medicine, Proc. Phil. Patholog. Soc. iii, 165-181, 1900.

Vestberg, A., Om de Sjukliga Företeelsernas Biologiska Betydelse, Upsala Läkareförenigens Förhandlingar, 1903.

Virchow, R., Morgagni und der Anatomische Gedanke, 1894.

Welch, W. H., Biology and Medicine, The American Naturalist, xxxi, 756-766, 1897.

THE RELATION OF PATHOLOGY TO OTHER SCIENCES

BY JOHANNES ORTH

[Johannes Orth, Professor of Pathological Anatomy and General Pathology, University of Berlin, since 1902. b. Wallmerod, Herzogthum Nassau, January 14, 1847. M.D. Bonn; Assistant am Pathologischen Institut, Bonn, 1870-73; *ibid.* Berlin, 1873-78; Regular Professor, University of Göttingen, 1878-1902. Privy Medical Councilor; member of the Royal Scientific Deputation for Medical and Sanitary Science; Royal Association of Science of Göttingen; Imperial Leopold and Caroline Academy of Natural History; and a number of scientific and learned societies. **Author of** *Cursus der Normalen Histologie; Pathologisch-anatomische Diagnostik; Manual of Pathological Anatomy;* and numerous other memoirs and works on pathological anatomy.

WHOEVER has to speak of pathology in general, as is my task, must first determine what he includes in pathology, for the ideas which are evoked by this term are not always the same. The opinion is common that pathology is synonymous with "science of disease," "nosology;" but this, as Rudolph Virchow [1] has attempted to prove repeatedly, is not true. Doubtless disease, or rather the diseased individual, is the most important object of consideration of pathology; it is, however, not the only one. The conception of pathology is much more comprehensive. To pathology belongs, on the one hand, every deviation from the normal structure and the normal composition of the body, and, on the other, every deviation from the normal function of its parts. It therefore includes every variation from what we consider the type of an organism. Variation from type is, however, not disease. Disease is, as Boerhaave was the first to say, "*Vita praeter naturam,*" and life presupposes activity. When there is no functional activity and thus no deviation from normal function, there can be no disease. But not even every functional variation from the normal indicates disease. The variation must be pernicious in character, if it is to bear the name of disease. When there is no detriment, there is no disease, although whenever a variation from the normal exists, we have to do with a pathologic condition, no matter whether the variation is morphologic or functional.

Purely morphologic variations without detrimental influence on the rest of the body are found, especially among anomalies and malformations, and who will deny that these belong to the realm of pathology? An individual with a supernumerary nipple, a person with polydactilism, a woman with uterus septus or bicornis, all are pathologic, although none are sick. Thus, while the biologic phenomena of the diseased state form the greater part of the realm of pathology, they do not complete it. Its limits must be extended much further, but how far is the point of contention.

[1] *Handb. d. spec. Pathol. u. Therapie,* 1854, pp. 6 ff.

Many may consider the statement of Virchow[1] a witty paradox when he says that the development of new species really belongs to the realm of pathology, as a new species must find its origin in a variation or deviation from the preceding type, and variation from type is pathologic. Thus the whole teaching of evolution, the science of phylogeny, is to be considered part of pathology. I share throughout Virchow's opinion, and in my work on inherited and congenital diseases, recently published,[2] I have again given this fact expression that we must presuppose a variability of the embryonal protoplasm (*Keimplasma*) and that variation or deviation from the previous type either acquired or inherited or even arising from external influences is the necessary preliminary to the formation of a new species, subspecies, or variety. I would not, however, like to go so far as to call everything arising in this way pathologic, no more than I can consider it pathologic when, by immunization, a man is made better than he was before. Such a man varies from the type of normal man, but is not pathologic, because the variation is useful and appropriate. Only variation which is inappropriate or useless is pathologic. I realize that it may often be difficult to determine the limits of the inappropriate and useless and thereby pathologic, especially in the development of varieties and races. Thus, I should not hesitate to class the Crested Polish fowl with its exencephalocele as pathologic, while I should exclude those breeds which the animal breeders have made for useful purposes from pathology, no matter how near the pathologic the products of skill might be.

Variations from type occur in inanimate as well as animate nature; there are malformed crystals just as there are malformed plants, animals, and persons, but we are not accustomed to speak of a pathology of crystals or stones, but only of plant, animal, and human pathology, for only with living beings can we rightly speak of useless, inappropriate, or pernicious variations from the normal.

Human pathology, undoubtedly the most momentous and important for us, has made but little use of plant pathology as yet, although there can be no doubt that many conclusions for general pathology as for general anatomy are to be drawn from botany. The reaction of plant cells to unusual conditions, and the morphologic and functional disturbances which occur under such circumstances are easier to observe, and may well serve as guides to the understanding of similar processes in animal or human cells. Experimental pathology has already made use of plants in its investigations,[3] but only recently have we begun to give more attention to the spontaneous diseases

[1] R. Virchow, *Rassenbildung u. Erblichkeit, in Festschrift für Batian*, 1896.
[2] Orth, *Angeborene u. ererbte Krankheiten u. Krankheitsanlagen, in Krankheit und Ehe*, herausgegeben von Senator u. Kaminer, München, 1904, p. 26.
[3] O. Israel, *Biolog. Studien mit Rücksicht auf d. Pathol. Virchow's Arch.* 141, p. 209, 1895.

of plants, especially since we have learned how great a rôle parasitism plays in vegetable as well as human pathology. At the head of the parasitic problems of human pathology of the present day stands that of the etiology of tumors; here cancer cells, here cancer parasites, so sound the battle-cries, and a parasitic new formation in the vegetable kingdom, the club-root of turnip, did not only have to furnish the paradigma of cancers in man and beast, but some investigators have even gone a step farther and see in *Plasmodiaphora brassicae*, the parasite of club-root, the exciting cause of animal tumors or at least a close relation of such cause.[1]

Very different is the relation of human to animal pathology, not only on account of the closer relation between man and animal, by reason of which a comparison of observations between animals, especially the higher vertebrates, and human pathology is more permissible, but also because the questions to be decided experimentally must be proved in the main on animals.

Even though a complete agreement between the phenomena of human and animal pathology cannot exist, as the function and construction of the animal body and its organs do not entirely agree with those of man; even though many diseases which attack man do not occur in animals, still analogies are not wanting and the similiarity is greater the higher the group among the vertebrates to which the animal in question belongs. An especial advantage of comparative animal pathology is that the necessary material is not only easier to obtain than the human, but that particularly by voluntary killing of pathologic animals accurate morphologic investigations can be made at any desired stage and on perfectly fresh tissues free from cadaveric changes. Especially valuable conclusions can be drawn in those diseases, which are common to man and animals, the zoönoses and the anomalies of formation, the simpler ones as well as the monsters in the narrower sense.

A somewhat neglected realm of comparative pathology has recently attracted the attention of pathologists in more and more increasing degree; namely, tumor formation in the lower animals.[2] From their construction we may expect to draw valuable conclusions in regard to the pathology of human tumors, not only in the morphologic but also in the genetic direction. One point especially comes into consideration, which also plays an important part in the utilization of animal pathology in other directions, the possibility of purposeful inoculation experiments from animal to animal.[3]

Unfortunately the great value of experimental research for all

[1] Gaylord, *Zeitschr. f. Krebsforschung*, I, 1903.
[2] Pick u. Poll, Berlin, Klin. Wochnsechr, 1903, p. 518.
[3] C. O. Fenger, *Experim. Untersuch. über Krebs bei Münsen, Abh. f. Bakterio.* xxxiv, p. 28, 1903; Borrel, *Epithél. infectieuses Ann. de l'Inst. Pasteur*, 1903, no. 2.

branches of pathology [1] is not sufficiently known among the laity, and attempts through governmental interference to lay difficulties in the way of experimental investigation (vivisection as it is called by the laity, scientific animal torture according to its opponents), are constantly being made, not seeing that misuse of it, even if it should occur, is considerably outweighed by its undeniable value. Pathologic anatomy, bacteriology, pathologic chemistry, and above all, pathologic physiology, cannot fulfill their scientific value without animal experiment. A large part of the progress in pathology is bound up with experimental research. Every advance in pathology has sooner or later been of use to man. Could our progress in the pathology of the infectious diseases, and our progress in the prevention and treatment of them, have been made without experimental pathology? The explanation of the origin of tumors must also finally arrive by experimental investigations, and just there it will be of especial value to be able to carry on the experiments on the same kind of animal in which the tumor naturally occurs. If we should succeed in finding a specific, probably parasitic cause, the possibility of demonstrating the pathogenicity of this disease-producer on animals of the same sort is incalculable. But such experiments presuppose exact knowledge of the pathology of the animals experimented upon, that is, comparative pathology, and many discussions of the present day have turned on the point whether changes which were found after the experiment were results of the experiment or chance pathologic findings to which the experiment had no genetic relation. If one does not know what kind of tumors occur in the organs of the animal which he is using for experimental purposes, he will easily fall into the danger of considering new formations as the result of the microörganisms injected by him and will report having produced a tumor when merely a spontaneous new growth existed.

So far I have considered animals only as passive objects of experimental pathology. I have spoken of animals and plants merely as the most important subjects for comparative pathology. There are, however, much closer relations between pathology and botany and zoölogy. Both these sciences have had increasing importance for pathology, as surer proof was brought that the most important causes of disease belong to the plant and animal kingdoms.

Investigation of the causes of disease, of the different conditions which form the basis of deviations from normal types, belongs as much in the realm of pathology as the study of these deviations and their development itself. The etiology and pathogenesis are a part of pathology, and it is especially through them that patho-

[1] R. Virchow, *Ueber den Werth des pathologischen Experiments*, Internat. Med. Congress, London, 1887, Berlin, 1899.

logy has its closest relationship with the other sciences. Mechanics, general and cosmic physics, geology not less than geography, inorganic as well as organic chemistry, social and military history, sociology, and commercial science, etc., must all be considered for the enlightenment of the etiology of disease and the explanation of the appearance of disease, especially in regard to time and place (historic geographic pathology). But above all stand zoölogy and botany, for the most important and most common diseases are produced by living beings, by parasites.

It is an old statement in pathology that a parasitic relation exists in disease. For a long time the disease as such was thus personified; it was spoken of as an organism within the organism, a parasite, which as Wunderlich [1] said, was anthroposed or phytomorphosed in every way. To it was ascribed an existence, a growth, limbs and organs, a power of endeavor and of thought, even a sickness, death, and finally a corpse. Pathology has done away with this conception. It is true that we still speak of the disease, of cholera, typhoid fever, pneumonia, etc., and that in practical medicine we still speak of treating this or that disease. A treatment for syphilis, for diphtheria, or some other disease is recommended as if we spoke of something tangible, independent. But all this is only for convenience of expression, and we know very well that what we call a disease is not an entity but only a group of phenomena which have for their basis a common cause. There are really no diseases, but merely sick men, diseased organs, diseased tissues, diseased cells, and it is the cause of these disturbances which brings about the special phenomena which we observe in the diseased part.

This cause may be a parasite. Centuries ago the opinion was occasionally expressed that diseases were caused by living beings, which disturbed the life-processes in the human body. In the middle of the last century the view that there must be *contagium vivum* was victoriously upheld by Henle,[2] but only in the last decades of the nineteenth century was actual proof brought forward that by far the commonest causes of disease are living organisms which live parasitically on or in the human body. The disease is not the parasite, but one parasite or many parasites cause those variations from the normal structure and function of parts of the body which in their entirety we call disease.

By parasitology a close union is made between pathology and the described natural sciences and thus with general biology.

The great biologic question as to the origin of the lowest being is related principally to the human parasites. In spite of the statement of the great English physician Harvey, "*Omne vivum ex ovo,*"

[1] Wunderlich, *Hdb. d. Patholog. u. Therap.* I, p. 12, 1852.
[2] Henle, *Hdb. d. Ration. Pathol.* II, 2 p. 457, Braunschweig, 1853.

the doctrine of spontaneous generation, which ruled for thousands of years, had not vanished from science, and in the beginning of the last century natural philosophy treated with preference on the beginning of life, and some are not lacking in our day who believe that they see in the doctrine, that the tissues of our bodies break up in decomposing into small organisms,[1] an expression of the immortality of the life principle.

That the large intestinal worms do not arise from the dirt of the intestinal canal, from saburra, but that for them Harvey's rule holds, has been shown by both zoölogists and pathologists. For the smallest beings we may mention the chemist, L. Pasteur, with the physician, Robert Koch, the former of whom conclusively disproved the spontaneous generation of microörganisms; the latter as the discoverer of the methods which permitted us to ascertain simply and surely the constancy of form of a microörganism and to give incontrovertible proof that in every single microörganism the law of generation was true, not entirely in Harvey's sense, but in the more general form: *Omne vivum e vivo ejusdem generis.*

But it is not only general biology which has been furthered by the parasitology of the physician, but also special biology and the systematic classification of parasitic animals and plants. Just here is plainly shown that pathology cannot in any way be separated from the other natural sciences, as it is not only the receiver which makes practical use of scientific discoveries, but also the producer which by its own effort, and through independent performances furthers science. The modern development of bacteriology, the determination and elaboration of exact methods of investigation, the morphology and biology of bacteria, have not been entirely developed by botanists, but it has been and still is physicians and pathologists who may claim a large part of the results as due to their efforts.

The same relation in working together exists between pathology and zoölogy in regard to the parasitic animals. Here the points of contact of the two sciences are doubled, for on one hand the change of generations of many human parasites, their occurrence in different hosts, as well as the fact that animals may be the simple conveyers of parasites, required the human parasitologist to bring the animal world into the realm of their investigations; on the other hand, the morphology and systematic study of the parasitic animals themselves has been ascertained with considerable assistance from pathologists. In the first class I will only recall the joint work of pathologists and zoölogists on trichinosis.[2] In determining the relation of this

[1] R. Arndt, *Unters. über d. Entschung von Kokken und Bakterien in organischen Substanzen*, Virchow, *Arch.*, 82, p. 119, 1880; A. P. Tokker, *Versuch. einer nauen Bakterienlehre*, 1903.

[2] Zenker, *Arch.* I, p. 90; Leukart, *Unters. üb. Trich. spiral.* 1866, R. Virchow, *Lehre von den Trichinen.*

disease in pigs and other animals to that in man; malaria and the rôle which anopheles play therein; the recent investigations on the conveyance of plague and other infectious diseases by animals. Names of physicians like Küchenmeister,[1] Davaine,[2] and others have given human parasites their final place in zoölogy. I wish also to call attention to the very recent investigations concerning protozoa as disease-producers, one of the most burning questions of modern pathology, a question of extreme importance, and also of correspondingly great difficulty. Unfortunately, investigations on the parasitic protozoa remain still in their infancy, but even on this question the pathologists of Europe and North America may demand recognition of their zealous work.

Closest and most numerous are, of course, the relations of pathology to anatomy and physiology. Just as the study of the normal, typic man is divided into anatomy and pathology with physiologic chemistry, so also is pathology (apart from etiology and pathogenesis) made up of pathologic anatomy and pathologic physiology with pathologic chemistry. Just as health and disease pass imperceptibly into one another, so there can be no sharp line drawn between pathologic and normal anatomy, normal and pathologic physiology. These studies are not different sciences, but branches of the same scientific tree with the same stem, the same roots. Their methods of investigation are mainly the same. Discoveries in one generally mean progress in the others..

The time is not long past when instruction in pathologic anatomy in our universities was in the hands of the professor of normal anatomy, and when men like Joh. Fr. Meckel, Johannes Müller, and others enriched and fostered normal as well as pathologic anatomy. Pathologic anatomy is only conceivable on a basis of normal anatomy, and a glance at the history of medicine shows how every progress in normal anatomy has produced an increase in the knowledge of pathologic anatomy. Only the flourishing of anatomy in the sixteenth century made the development of pathology to a separate science during the ensuing century possible. But here also pathology was not only the receiving but frequently the producing science. Pathologists not only enriched anatomic and histologic methods, but contributed largely to the development of accurate anatomy, the general as well as the special. Who does not think in connection with "general anatomy" of Rudolph Virchow,[3] the man who coined the famous words "*omnis cellula e cellula*" corresponding to Harvey's "*omne vivum ex ovo?*" That saying while resting in great part on

[1] Küchenmeister, *Die in und an d. Körper d. lebend. Menschen vorkommenden Parasiten*, 1878, 1879, 3. Aufl.

[2] Davaine, *Traité des Entozoaires*, Paris, 1877, 2. Aufl.

[3] *Die Cellularpathologie in ihrer Begründung auf physiologische und pathologische Gewebelehre*, 1. Aufl. 1858; 4. Aufl. 1871.

pathologic observations, is equally true for pathologic and normal anatomy.

In connection with special anatomy it will suffice to refer to the progress in the anatomy of the brain, especially to the course of its fibers, in order to show how much pathology has contributed to the knowledge of normal structure. The great progress which the fine brain anatomy made in the last decades of the last century is due in large part to pathologic observations, medical investigations, methods conceived by physicians, and the result of investigations has been brought forward in connected form, especially by medical writers.

The same is true, but even to a higher degree, of physiology, the pathologic branch of which has unfortunately not received the deserved recognition and fostering in every place as a separate science, but which nevertheless has not been neglected by scientific medicine.

A large part of our knowledge of human physiology has been obtained by the observations of functions changed by disease as they appear as symptoms of disease in man or are produced artificially by experiment on animals. Where would the physiology of the brain be, if pathology had not made clear the position of the centres and the course of the tracts from the constantly recurring symptoms and lesions and pathologic experiment had not proved the correctness of the conclusions which were drawn from human observations?

What would general cellular physiology be, if observation of the behavior of cells under varying life conditions had not given us information concerning the processes under normal conditions?[1] Is not general cellular physiology rather a product of cellular pathology? Was it not a pathologist, R. Virchow, who introduced the idea that the cell is the final form element of all vital phenomena, and who arrived at this conclusion not least through pathologic observations?

From the deviations one recognizes most readily the law. There is no problem of general biology which has not received enlightenment and explanation from the experiences of pathology. The doctrine of heredity, to name only a few of these problems, plays no small rôle in pathology, and many cases of pathologic heredity throw a clear light on the subject and nature of heredity in general. The latest discoveries of pathology in the realm of hematology, the doctrine of agglutinins and precipitins, has already led to most valuable revelations respecting the general biologic question of the blood relationship of animals with one another, and of animals with man. The blood of anthropoid apes and man shows similar behaviors, but differs from the blood of other animals.

[1] Verworn, *Allgemeine Physiologie.*

Especially numerous and close relations exist between pathology and that branch of biology which treats of the development of the human and animal body, and these relations are daily becoming closer and more numerous, as more and more frequently it can be proved or at least made probable, that pathologic phenomena of all kinds form the basis of ontogenetic disturbances of the greatest variation.

An important difference exists between normal and pathologic anatomy, in so far as the genetic consideration plays a much greater rôle in the latter than in the former. Finished conditions form the basis of descriptive anatomy. Pathologic anatomy must always consider phases of development and none of its observations can be understood if their origin cannot be explained and if the original condition and the further development of its changes cannot be determined. The original condition, however, leads more and more frequently back to the time of embryonal development. It is to the eternal merit of Joh. Fr. Meckel,[1] the anatomist and pathologist, of Halle, that he showed for the first time in the case of a malformation of the intestinal diverticulum that the essential part of the variation from the normal consists in this, that a condition which is normal for a certain period of embryonal life, but which should only have a transient existence, is retained and is always recognizable in later stages of development, even though changed by the progressive growth of the part. This demonstration was the more important and valuable, as it treated of a theme which had hitherto been the ground of the most remarkable genetic theories. The apparently planless variation from type was explained as the work of demons or devils or as a freak of creative nature (*lusus naturae*). Now, it was shown for the first time that also in the realm of malformations, order and law governed the process and not arbitrariness and freakishness, and that we must consider the embryonal development of these malformations if we would understand and explain these methodic processes.

Thus was founded the doctrine of imperfect development and growth, and as the basis for the explanation of malformations (*Hemmungs-Missbildungen*) it has been especially fruitful, as the fissures about the face, malformations of the female genitals, and congenital malformations of the heart will show, but that they have not yet closed the list is shown by the recent investigations of cystic kidneys, which have proved these to be due to a checking of the development of the embryonal organs. These examples show that disturbances of embryonal development are not only of importance in causing variations from the type, such as malformations, but also for disease-processes in the narrower sense, which originate most readily in malformed parts or organs. The idea that congenital heart

[1] J. F. Meckel, *Handb. d. pathol. Anat.* I, p. 553.

disease was due to endocarditis in fetal life was largely due to the knowledge of the susceptibility of the malformed part to secondary so-called chronic inflammation. This is true not only of the macroscopic conditions like those mentioned, but it also favors the idea that incompleteness in the formation and the later development of a part cause a local disposition to disease. But this is only one side of the relationship between disturbances of development and disease. Another, perhaps even more important, is that which treats of the development of tumors on a basis of disturbance of development. The tumors of undescended testicles, the origin of new formations from displaced adrenal fragments, are as familiar to pathology and as surely established as the occurrence of dermoid cysts, which can only be explained on the basis of the history of development. The well-known theory, according to which all tumors depend on disturbances in embryonal development, still lacks sufficient proof. Both pathologists and embryologists have been successful in showing, however, that one tumor at least, the dermoid of the ovary, only finds a satisfactory explanation in the presence of derivatives of all three embryonal layers, thus indicating a very early disturbance of development.[1] These tumors are closely related to malformations and pass without sharp division into true monstrosities. The study of all malformations, not only those due to impeded development and which no one attempts to deprive pathology of, is not to be separated from the study of normal development, for the origin of malformations goes back to the earliest embryonal period, and not only malformations of the whole body but anomalies of its single parts can only be understood and their origin explained in the light of normal developmental processes.

On the other side, experimental teratology, which is doubtless a branch of pathology, has made most important advances in the knowledge of the laws of normal development, the laws which govern the details of the regular formation of the embryo. Here also no sharp line can be drawn between pathology and embryology. Pathology takes its place alongside of embryology, with equal right and equal importance.

Thus we see pathology placed centrally among the biologic sciences, bound inseparably to all of them, not subordinate to any but their equal, receiving help from all sides but giving as much in return. Lastly, it must be stated that it is the problem of life which forms the subject of pathologic work. Even though it wanders in its own ways, and possesses its especial questions, it is finally led to the general question of every biologic investigation.

[1] Marchand, *Eulenburg's Real Encyclopaedie*, xv, 432, 1897; Bonnet, *Ergebn. d. Anat. u. Entwicklungsgesch.* IX, 820, 1899; Wilms, *Die Mischgeschwülste*, 1899–1902.

Points of contact with philosophy are always presented by these general biologic problems, and we need only name Lotze,[1] the physician and philosopher, and his work on *General Pathology as a Mechanical Science*, to find the close relationship between philosophy and pathology personified in modern times. Metaphysic consideration of empiric assertions is necessary, as Kant has taught, to draw general conclusions and formulate general rules and laws from the observation of nature. Biology, and not least, pathology, lead everywhere to the limits of our knowledge of nature, where fixed knowledge finds its end, where we must, with Du Bois Reymond,[2] acknowledge our ignorance of what lies beyond, but where philosophic contemplations point a higher and more general way out of our difficulty. These limits to our knowledge are not lasting, however, for pathology. We will not remain in ignorance as long as the knowledge of healthy and diseased life progresses, and the boundaries of natural science and philosophic contemplation of the problems are being extended. Increasing knowledge of facts must be the basis of philosophic contemplation, if this would have real value.

There was a time in pathology when philosophic conceptions outweighed all other considerations, and when it was believed that all the problems of general biology and those of general pathology could be solved by pure reasoning. This period of natural philosophy was as unfruitful for real progress in pathology as the period of dogmatism in the Middle Ages, when Aristotle and Galen were looked upon as the sum of all wisdom, and pathology was nothing more than philology, as all scientific work consisted principally in criticising and commenting upon the Greek writings.

This changed only after we emancipated ourselves more and more from the old dogmatic belief and through original investigations laid a true scientific foundation for pathology. The maxim of the great Morgagni,[3] "*Nulla autem est alia pro certo noscendi via, nisi quam plurimas et morborum et dissectionum historias, tum aliorum tum proprias collectas habere et inter se comparare*," as well as his other, "*Non numerandae sed perpendendae sunt observationes*," had to receive general recognition before pathology was enabled to take its place among the other natural sciences. This place it had lost, for in the renaissance of science in the sixteenth century pathology stood in close relation to the other natural sciences; and medicine was for centuries the bearer of all natural science and included all other sciences within itself, so that not only did the teachers of other sciences belong in many cases to the medical faculty, but zoölogy

[1] Lotze, *Die allgemeine Pathologie und Therapie als mechanische Naturwissenschaft*, Leipzig, 1842.
[2] Du Bois Reymond, *Ueber die Grenzen des Naturerkennens*, Naturforscher-Ver-Sammlung in Leipzig, 1872.
[3] *De sedibus et causis morborum, per anatomen indagatis*, 1761.

and botany, physics and chemistry, were taught by physicians. We need only recall Haller and his great teacher Boerhaave, who successively occupied the chairs of botany and chemistry, of practical and theoretic medicine, and attained fame in all these branches. All this has changed in the course of time; the children have separated from their mother and have further developed themselves, and their development to great sciences has proceeded more rapidly than that of pathology. The time is not long past when the emancipated looked down on pathology and would not recognize it as an equal science. Did not Virchow find it necessary, before the congress of German naturalists, in 1867,[1] to insist on the scientific equality of pathology, and to demand that the so-called exact natural sciences should recognize pathology as an equal companion.

In fact, as pathology (excepting in purely etiologic studies) cannot do without physics and chemistry, as she also strives to refer pathologic phenomena to physical and chemic laws, so she has given something to these sciences and even to the present time has furnished workers which have assured themselves a lasting place in the history of exact sciences. Is not the mention of the name of the physician, Robert Mayer, the discoverer of the law of conservation of energy, and of Helmholtz, who began his professorship in Königsberg with lectures on general pathology, sufficient proof? The literature of Röntgen, radium, and other light-rays shows sufficiently how to this day pathology takes part in the investigation of physical problems.

These investigations lead to another especially important field, that of chemistry. Questions which were determined in the chemical laboratory of my institute, the proof, namely, that by the effect of radium rays on cancer tissue impediments which stood in the way of the action of preëxisting cytolysins are set aside, are nothing but chemic questions. Thirteen years ago I stated in a rector's address,[2] that only pathologic chemistry on a basis of cellular pathology could take us further in the study of infectious diseases, that the chemistry of bacteria, the normal and pathologic chemistry of the cells, was the problem of the future. This statement can be enlarged upon; in whatever branch of modern pathology we seek progress, we finally always meet chemic questions, and it needs no prophet to tell us that the greatest progress of pathology in the immediate future will be along the lines of chemistry. In all directions pathologists have united with chemists to further the study of the chemistry of proteids. Physicians and pathologists have furthered the knowledge of precipitins, agglutinins, and lysins of various sorts, not only in their practical but also in their purely scientific relations, and have begun to study these substances along different lines.

[1] *Ueber die neueren Fortschritte in der Pathologie*, Vortrag in der 2. allgemeinen Sitzung am 20. September, 1867.

[2] *Ueber d. Fortschritte der Aetiologie*, Göttingen, 4. June, 1891.

Pathology stands in close relation not only with that group of physical sciences which treat of life-processes and living organisms but also with the exact physical sciences. To these also many bridges lead, over which the connecting links flow in both directions, pathology giving as well as receiving. A separation of pathology from the other sciences could therefore only be made by force, for pathology forms an integral part of the science of life, biology. I do not consider it just, therefore, that in this Congress, bacteriology, which draws its greatest importance from that part which belongs to pathology, which is thus, principally, a part of pathology, has been placed by itself in Division C, "Physical Sciences" (*Naturwissenschaft*), and pathology in Division E, "Useful or Utilitarian Sciences." Is bacteriology not an eminently useful science? Has it not found the most widespread use in medical practice? Have not other branches of pathology, and especially pathologic anatomy, been reproached because it has done little for the prevention and treatment of disease, while bacteriology has done much in this direction? Yet bacteriology is put under physical sciences and pathologic anatomy with the rest of pathology among the utilitarian sciences! On what grounds can we consider human pathology as a different sort of science from the pathology of plants? If we class plant pathology with plant morphology and physiology as a part of biology (as is right), one must do the same for human pathology and place the biologic sciences in the closest relation with human anatomy and physiology. Human pathology is as much natural science and a separate branch of biology as is phytopathology, and pathology is no more a utilitarian science than normal anatomy and physiology. Is medical activity conceivable without anatomy and physiology? As little as without pathology! Has pathology only importance through its relation to practical medicine? Not at all. Pathologists also prosecute their scientific studies without regard as to whether their work will be of immediate practical value or not. They also follow the inner motive toward knowledge and truth. They wish to satisfy that desire for increased knowledge which is in every human breast, to share in disclosing the secrets of nature. If the acquisitions of pathology have had a greater and more immediate effect on medical treatment than those of anatomy and physiology, that does not alter its scientific quality in the least; that they were also useful has never injured other sciences or lessened their scientific value. No one will value chemic and physical sciences less because they have been the basis of the wonderful advance in technic and industry, as displayed to the wondering eyes in this exposition. Pathology rejoices in its relation to practical medicine and would neither miss nor lessen it, for as physics and chemistry constantly receive from practice stimulus to new endeavors and progress, so also pathology needs uninterrupted relation to medical art. But it remains first of all an independent physical science, which in its three branches, pathologic anatomy, physiology, and chemistry, stands on an equal plane with normal anatomy and physiology and physiologic chemistry, with them and etiology forming the scientific basis for practical medicine.

But as for ages past a certain socialistic or rather humanitarian spirit has ruled in medicine (and to medicine pathology must always belong), which effected that with all pride over scientific demonstrations the real and true joy over scientific progress was not reached, if not only wisdom and knowledge were furthered, but also something of value has been accomplished for the general good, so it may also remain in the future. Pathology will be recognized as a natural science, but it will be its pride and joy also in the future to be and to remain a utilitarian science.

THE BEHAVIOR OF NATIVE JAPANESE CATTLE IN REGARD TO TUBERCULOSIS (PERLSUCHT)

BY SHIBASABURO KITASATO

[Shibasaburo Kitasato, Director of the Government Institute for the Study of Infectious Diseases. b. December, 1857, Kumamoto, Japan. Imperial University of Tokio, 1882 (Igakushi); Special Course in Koch's Institut fur Infection, Skrankherten, 1885–92; Igaku-Hokushi (Japan) in 1891; Professor (Germany), 1892; Decoration of the Third Order of "Rising Sun," 1894; Director of the Government Institute for the Study of Infectious Diseases, 1899; Adviser to the Government Sanitary Bureau, 1903. Member of the Japanese Medical Society (President); Japanese Hygiene Society (Vice-President); Reale Società Italiana d'Igiene (Honorary); Sanitary Institute, London; American Society of the Tropical Medical (Honorary); Medical Society of Manila; Harveian Society of London; New York Academy of Medicine (Honorary); Academy of Sciences, St. Louis.]

In Japan it is a fact of common knowledge that the native Japanese cattle are free from tuberculosis (perlsucht) under ordinary conditions, while imported and mixed types of cattle (that is, such as descend from foreign cattle on the father's side, from native cattle on the mother's) contract the disease. This fact would be a very noteworthy one if we could suppose that our native animals are naturally insusceptible to tuberculosis, and are not so simply because they have not had the opportunity to become infected. As far as I know, no race of cattle is known to us which can prove ownership to a real natural immunity against tuberculosis. The claim has been made often enough, but each time the falsity of the claim could be demonstrated through inoculation experiments. To determine the position of the native Japanese cattle in regard to tuberculolsis the following experiments were performed.

Before relating these experiments, however, I would like to make a few general remarks concerning tuberculosis of the human race in Japan.

Table I. — Mortality From Tuberculosis in Japan Between the Years 1892 and 1901.

Year.	Population.	Total number of deaths.	Pulmonary Tuberculosis.	Other respiratory diseases.
1892	41,044,739	894,875	57,292	109,705
1893	41,399,874	930,009	57,798	133,162
1894	41,788,335	845,293	52,888	98,963
1895	42,210,179	854,392	58,992	96,531
1896	42,623,931	904,473	62,790	105,697
1897	43,064,658	875,103	65,597	101,360
1898	43,540,768	891,339	72,708	113,365
1899	43,960,008	920,340	75,226	108,262
1900	44,457,973	910,517	78,972	120,761
1901	44,968,769	932,365	81,669	123,929

Year	The relation of the total mortality and mortality from tuberculosis to the total population (compared with 1000 inhabitants).			Percentage of tuberculosis mortality to the total mortality.	
	Total mortality.	Pulmonary tuberculosis.	Other respiratory diseases.	Pulmonary tuberculosis.	Other respiratory diseases.
1892 ...	21.80	1.40	2.67	5.40	12.26
1893 ...	22.46	1.40	2.73	6.21	12.17
1894 ...	20.23	1.27	2.37	6.26	11.71
1895 ...	20.24	1.40	2.29	6.90	11.30
1896 ...	21.22	1.47	2.48	6.94	11.70
1897 ...	20.32	1.52	2.35	7.50	11.58
1898 ...	20.47	1.76	2.37	8.16	12.72
1899 ...	20.94	1.71	2.46	8.17	11.76
1900 ...	20.48	1.78	2.72	8.67	13.26
1901 ...	20.73	1.79	2.76	8.76	13.29
Average	20.88	1.55	2.54	7.41	12.19

Mortality from tuberculosis in the eight largest cities, all of them having more than 100,000 inhabitants, and in the other towns of Japan during the years 1899 and 1900:

TABLE II.

Place and Year.		Number of inhabitants.	Total mortality.	Pulmonary tuberculosis.	Tuberculous meningitis.	Intestinal tuberculosis.	Tuberculosis other organs.	Total tuberculosis.	Other respiratory diseases.
Tokio	1899	1,468,953	29,274	4,238	343	499	37	5,117	2,812
	1900	1,497,675	27,869	4,254	336	458	56	5,104	3,767
Kioto	1899	356,956	7,905	1,132	99	168	14	1,413	918
	1900	364,673	7,703	1,204	159	176	25	1,564	803
Osaka	1899	835,203	16,407	2,257	175	316	9	2,757	2,002
	1900	865,021	15,991	2,431	221	337	17	3,006	2,036
Yokohama	1899	195,364	2,829	278	40	44	00	362	353
	1900	201,036	2,487	401	32	34	3	470	305
Kobe	1899	225,970	5,360	711	36	88	1	836	590
	1900	240,917	4,808	719	27	74	5	825	642
Nagasaki	1899	114,144	1,489	196	12	15	1	224	192
	1900	125,231	1,804	234	22	34	4	295	189
Nagoya	1899	243,767	4,622	543	29	84	3	659	591
	1900	252,068	4,675	597	19	65	1	682	627
Hiroshima	1899	126,039	1,937	207	3	24	4	238	305
	1900	133,732	2,179	256	16	20	2	294	289

TOTAL OF THE EIGHT CITIES.

1899......	3,566,394	69,823	9,562	737	1,238	69	11,606	7,663
1900......	3,680,351	67,516	10,097	832	1,198	113	12,240	8,658

All Other Places.

1899......	40,393,614	862,264	46,376	2,014	7,178	435	56,003	105,792
1900......	40,777,622	843,228	49,428	2,344	7,228	531	59,531	116,613

Sum Total of Entire Japan.

1899......	43,960,008	932,087	55,938	2,751	8,416	494	67,609	113,455
1900......	44,457,973	910,744	59,525	3,176	8,426	644	71,771	125,271

The Relation of the Total Mortality and Mortality from Tuberculosis to the Number of Inhabitants (Calculated to 1000 Inhabitants).

Place	Total mortality.	Pulmonary tuberculosis.	Total tuberculosis.	Other respiratory diseases.
Tokio	19.23	2.86	3.45	2.22
Kioto	21.63	3.24	4.13	2.38
Osaka	19.06	2.76	3.39	2.37
Yokohama	13.41	1.71	2.10	1.41
Kobe...............	21.78	3.06	3.56	2.64
Nagasaki	13.76	1.80	2.17	1.59
Nagoya.............	18.75	2.30	2.70	2.46
Hiroshima	15.64	1.78	2.05	2.29
Average of 8 cities ...	18.95	2.71	3.29	2.25
Other towns	21.01	1.18	1.42	2.74
Average figure.......	20.84	1.31	1.58	2.71

The Percentage of the Tuberculosis Mortality to the Total Mortality

Place	Pulmonary tuberculosis.	Total tuberculosis.	Other respiratory diseases.
Tokio	14.86	17.89	11.51
Kioto	14.97	19.07	11.03
Osaka	14.47	17.79	12.46
Yokohama	12.77	15.65	10.50
Kobe	14.06	16.34	12.12
Nagasaki	13.09	15.76	11.57
Nagoya	12.26	14.42	13.10
Hiroshima.........	11.25	12.93	14.43
Average of 8 cities .	14.31	17.36	11.88
Other towns	5.62	6.77	13.04
Average figure	6.27	7.56	12.95

A valuable paper on the statistics of tuberculosis has been written by Tamaye Ogiya, under the directorship of Professor Sata, from the pathologic institute at Osaka. This authoress states that during a period of three and a half years she has found among 250

TABLE III.

Place and year.		Population.	Total number of deaths.	Deaths from tuberculosis.	Total number of cattle.	Number of diseased cattle.	Perlsucht.
1896	M	43,815	807	23 (2.85%)	5,188	36	......
	O	......	......	......	......	......	......
1897	M	44,029	768	18 (2.34%)	5,585	16	......
	O	......	......	......	......	......	......
1898	M	43,357	936	32 (3.41%)	5,389	21	......
	O	35,026	697	60 (8.60%)	1,964	37	......
1899	M	43,370	805	31 (3.85%)	5,870	25	......
	O	35,104	704	80 (11.30%)	1,952	115	......
1900	M	43,821	778	33 (4.24%)	5.491	20	......
	O	35,346	673	51 (7.55%)	2,257	75	......
1901	M	44,093	701	48 (6.85%)	5,473	32	......
	O	35,526	642	39 (6.07%)	2,214	67	......
1902	M	45,043	762	58 (7.61%)	5,109	37	......
	O	35,607	684	42 (6.14%)	2,245	31	......
1903	M	......	766	62 (8.09%)	5,352	25	......
	O	......	678	88 (13.00%)	....	46	......

M., Mikato; O., Osaka.

TABLE IV. — SIMILAR TABLE FROM THE DISTRICT ABU IN YAMA-GUCHI-KEN FOR THE YEARS 1901 TO 1903.

Township.	Year.	Population.	Total mortality.	Mortality from tuberculosis.	Total number of cattle.			Number of diseased cattle.			Perlsucht.
					Native.	Mixed race.	Imported.	Native.	Mixed race.	Imported.	
Sammi	1901	3,246	51	1 (1.96%)	426	....	...	2	...	...	....
	1902	3,333	48	7 (14.58%)	436	....	...	1	...	...	....
	1903	3,262	73	3 (4.10%)	418	....	...	...	...	...	....
Udago	1901	2,022	33	1 (3.00%)	202	....	...	1	...	...	....
	1902	2,058	29	1 (3.44%)	203	....	...	...	...	...	....
	1903	2,015	43	....	203	....	...	...	...	...	....
Fukuga	1901	2,839	79	....	581	....	...	3	...	...	....
	1902	2,892	47	2 (4.25%)	511	....	...	3	...	...	....
	1903	2,901	71	2 (2.81%)	521	....	...	3	...	...	....
Susa ...	1901	5,223	98	5 (5.10%)	418	....	...	2	...	...	....
	1902	5,225	91	4 (4.40%)	414	....	...	3	...	...	....
	1903	5,292	106	4 (3.77%)	404	....	...	3	...	...	....
Akiraki	1901	2,924	49	3 (6.10%)	278	....	...	...	...	...	....
	1902	2,547	40	1 (2.50%)	257	1	1	3	...	...	....
	1903	2,603	39	1 (2.56%)	268	12	...	2	...	...	....
Nako	1901	3,957	78	4 (5.12%)	262	....	...	1	...	...	....
	1902	3,932	79	4 (5.06%)	262	....	...	...	...	...	....
	1903	4,058	54	1 (1.85%)	257	....	...	...	...	...	....
Ogawa	1901	4,180	106	9 (8.49%)	825	....	1	2	...	...	....
	1902	4,205	87	2 (2.30%)	734	9	2	1	...	...	....
	1903	4,247	86	6 (6.97%)	593	25	2	...	...	...	....
Tama-saki	1901	3,952	89	5 (5.61%)	309	....	...	2	...	...	....
	1902	3,994	83	4 (4.81%)	267	....	...	...	...	...	....
	1903	3,851	95	4 (4.21 %)	257	....	...	2	...	...	....

autopsies 116 cases of tuberculosis, amounting to 46.4% of the total. Of the tuberculosis patients, 20 (17.3%) were under 18 years, 96 (82.2%) were more than 18 years; among these patients she found 90 (77.6%) who presented lesions showing primary pulmonary tuberculosis, 12 (10.34%) who had primary intestinal tuberculosis. Among the latter 6 were more and 6 less than 18 years. Basing the statement upon this paper, it may be said that the occurrence of primary intestinal tuberculosis is not rare in Japan either among adults or children, although cow's milk is employed but little by us for the nourishment of children.

The table on the preceding page refers to districts in which man suffered from tuberculosis, but his cattle were free from it (the years considered are from 1896 and 1903); they are the districts Mikata and Osaka at Tasima in Hiyogo-Ken; these districts possess only native cattle.

The following table shows the number of cases of tuberculosis (perlsucht) among the slaughtered cattle found during the years 1901 to 1903 in five large cities :

TABLE V.

Place.	Native cattle.		Mixed races.		Imported.	
	Number of slaughtered head.	Perlsucht.	Number of slaughtered cattle.	Perlsucht.	Number of slaughtered cattle.	Perlsucht.
Tokio	72,780	40	5,299	2,293 (43.27%)	4	2 (50%)
Tokio	....	..	4,416 (calves)	7 (0.16%)	..	....
Kioto	17,643	..	1,139	566 (49.69%)	9	9 (100%)
Osaka	50,173	..	2,808	641 (22.89%)	41	13 (31.7%)
Yokohama ..	30,275	24	4,021	555 (13.85%)	..	....
Kobe	38,135	..	501	159 (31.73%)	..	....
Kobe	......	..	1,700 (calves)	....	..	....

It must be remembered that for a long time neither Tokio nor Yokohama have possessed any purely native cattle; it is highly probable that the tuberculosis animals mentioned in the foregoing table as native animals belonged in reality to mixed races, inasmuch as we have mixed races which resemble the native animals so closely that even an experienced veterinary physician cannot distinguish between them.

The examination of bovines (inclusive of the mixed races and the imported cattle) for tuberculosis (perlsucht) which has been carried on in Japan since last September and up to March of this year through tuberculin injections and other methods of examination, has given the following results:

TABLE VI.

Calculations are made on a basis of 1000 bovines; among them were found the following number of tuberculous:

Tokio-Fu	377.54	Yamagata-Ken	47.45
Kioto-Fu	133.44	Akita-Ken	36.72
Osaka-Fu	57.66	Fukui-Ken	273.98
Kanagawa-Ken	147.89	Ishikawa-Ken	20.19
Hiyogo-Ken	220.79	Toyama-Ken	91.93
Nagasaki-Ken	45.72	Toritori-Ken	14.49
Niigata-Ken	26.13	Shimane-Ken	2.94
Saitama-Ken	332.83	Okayama-Ken	11.43
Gumma-Ken	298.64	Hiroshima-Ken	36.27
Chiba-Ken	26.18	Yamaguchi-Ken	41.63
Ibaraki-Ken	162.72	Wakayama-Ken	79.79
Tochigi-Ken	187.50	Tokushima-Ken	39.89
Nara-Ken	209.37	Kagawa-Ken	1.47
Miye-Ken	114.30	Yehime-Ken	10.48
Aichi-Ken	333.47	Koochi-Ken	5.30
Shidzuoka-Ken	14.00	Fukuoka-Ken	188.05
Yamanashi-Ken	199.77	Oita-Ken	20.53
Shiga-Ken	169.83	Saga-Ken	75.74
Gifu-Ken	64.62	Kumamoto-Ken	60.06
Nagano-Ken	93.08	Miyasaki-Ken	55.21
Miyagi-Ken	97.20	Kagoshima-Ken	24.96
Fukushima-Ken	40.89	Hokkaido-Ken	87.30
Iwate-Ken	6.78		
Aomori-Ken	7.15	Average of all	56.71

The following table shows how little cow's milk is partaken of in Japan:

TABLE VII.

For every 10,000 inhabitants there are milk-cows in

Tokio-Fu	17.50	Akita-Ken	2.64
Kioto-Fu	15.78	Fukui-Ken	4.90
Osaka-Fu	8.21	Ishikawa-Ken	5.05
Kanagawa-Ken	11.81	Toyama-Ken	1.98
Hiyogo-Ken	5.60	Toritori-Ken	1.35
Nagasaki-Ken	5.88	Shimane-Ken	2.96
Niigata-Ken	3.91	Okayama-Ken	3.12
Saitama-Ken	2.82	Hiroshima-Ken	3.05
Gumma-Ken	7.68	Yamaguchi-Ken	5.63
Chiba-Ken	18.50	Wakayama-Ken	4.75
Ibaraki-Ken	1.75	Tokushima-Ken	1.70
Tochigi-Ken	2.70	Kagawa-Ken	2.52
Nara-Ken	2.86	Yehime-Ken	1.42
Miye-Ken	6.49	Koochi-Ken	2.00
Aichi-Ken	5.08	Fukuoka-Ken	3.31
Shidzuoka-Ken	9.46	Oita-Ken	1.36
Yamanashi-Ken	2.86	Saga-Ken	3.33
Shiga-Ken	5.08	Kumamoto-Ken	2.37
Gifu-Ken	6.37	Miyasaki-Ken	1.84
Nagano-Ken	9.35	Kagoshima-Ken	2.28
Miyagi-Ken	3.78	Okinawa-Ken	1.84
Fukushima-Ken	1.33	Hokkaido-Ken	10.16
Iwate-Ken	1.61		
Aomori-Ken	2.05	Average of all	5.65
Yamagata-Ken	4.87		

One milk-cow furnishes with us in the course of a year a daily average of five liters of milk. From this follows that in Tokio-Fu each individual consumes daily 8.85 cm., and in entire Japan 2.825 cm. of milk.

I. *Experiments concerning the Susceptibility of Native Bovines to Imported Perlsucht*

Experiment A. On January 22, 1904, we treated altogether 15 native calves of pure race (from three to six months old and having a body-weight of from 60 to 90 kilograms), which came from a region where, until now, no foreign cattle had ever been imported, in the following manner:

Each of seven animals was inoculated with 1 cm. of an emulsion containing a pure culture of highly virulent perlsucht bacilli; in two of the animals the injections were made into the cervical vein, in two into the abdominal cavity, in two into the trachea, and one was injected subcutaneously. Each of three calves was permitted to inhale 0.5 gm. of living but dried-up bacilli. The remaining five were each infected with 1 cm. of an emulsion from tuberculous organs, all of which contained very large numbers of tubercle bacilli; in one the intravenous route, in two the intraperitoneal, in one the intratracheal, and in one the subcutaneous route was chosen.

As control animals were employed five animals of mixed races. One of these received an injection of the emulsion of the tuberculous organs into the cervical vein, three into the abdominal cavity, and one was permitted to inhale a dried-up pure culture.

Before beginning the experiments, each of the calves was injected with 0.3 cm. tuberculin, to determine the existence of previous tuberculosis, but all were found free of the disease.

Three animals died 24 to 72 days after the experiment; the remaining 12 were killed after periods varying from 225 to 363 days.

One calf, which had been given an intraperitoneal injection of an emulsion of the pure culture of perlsucht bacilli, died as soon as the twenty-fourth day. At the autopsy it was found that the intraperitoneal lymphatic glands were swollen, and that the outer lower part of the left kidney contained yellowish nodules. The lungs were markedly hyperemic and contained but little air, but tubercles could not be demonstrated in any part of them. In the renal nodules the microscope revealed a small number of tubercle bacilli, which, when inoculated into the subcutaneous tissues of a guinea-pig, produced typical symptoms and signs of tuberculosis.

A second animal, which had been injected intravenously with the emulsion from tuberculous organs, was found dead on the fortieth day. The lungs contained very large numbers of tuberculous nodules and the glands of the thoracic cavity were swollen to an enormous size.

The third animal, which had received an injection into the trachea with the tuberculous emulsion, died after 72 days. The post-mortem examination revealed both thyroid glands hyperemic and swollen; at the point of injection the trachea was the seat of a mass the size of a pigeon's egg; the surface of this mass was covered with countless miliary tubercles. The lungs contained similar miliary nodules, and the right lung was even adherent to the pleura. The mesenteric glands were normal.

The remaining 12 calves were killed; three of them were more or less tuberculous. The one which had inhaled 0.5 gm. pulverized tubercle bacilli was killed after 259 days; the tuberculin reaction before its death gave a doubtful result. The autopsy showed the presence of a few very small nodules in the laryngeal mucous membrane and of one nodule in the anterior wall of the left cardiac chamber; this last one contained very many tubercle bacilli.

The second animal had been injected with 1 cm. of the emulsion from the tuberculous organs; it was killed after 256 days. The tuberculin reaction was positive before its death. The post-mortem examination showed the inguinal glands in the neighborhood of the point of injection very much swollen; the liver contained a few nodules; all the intraperitoneal glands were swollen, and some of them were already the seat of cheesy degeneration. The lungs were normal.

The third heifer had received an injection of 1 cm. of the emulsion from a tuberculous lung into its abdominal cavity; it was killed after 280 days. The tuberculin reaction before its death had also been positive. The section revealed the peritoneum and liver to be the seat of a small number of tubercles varying in size from a pea to a small bean; some of them were cheesy. Both lungs were studded with numerous grayish-white, hard miliary nodes.

The other nine animals were found to be entirely free from tuberculosis.

The five control animals were killed after from 217 to 364 days. The autopsy showed four of them to be suffering from tuberculosis and one to be free from it.

If the above-mentioned results are considered collectively it will be seen that from among 15 experimental animals six became tuberculous, while nine were demonstrated to be insusceptible. It is further worthy of note that the changes in the infected organs were relatively very slight.

From a review of the entire experiment it can be seen that the native Japanese bovines are to some extent susceptible to perlsucht experimentally, but only if doses of tubercle bacilli are inoculated so large as never to be received in the course of a natural infection.

We can conclude from this that our native cattle show so little susceptibility to perlsucht that natural infection appears almost impossible.

Experiment B. The same experiment was repeated on May 27 of this year; this time 33 native calves from 3 to 8 months old, and weighing from 40 kilograms to 90 kilograms were employed. The method of the experiment was exactly the same as in Experiment A. To obviate too frequent repetitions these experiments will be reported only briefly.

Fifteen of the animals were infected intravenously; in 10 pure cultures of perlsucht bacilli were employed, and in 5 the emulsion from tuberculous organs; 8 were infected intraperitoneally (5 with pure cultures and 3 with emulsion from organs); 3 were treated with inhalations of pure cultures, while the last seven were infected subcutaneously (5 with pure cultures, 2 with organ emulsions).

Four mixed race animals were employed as control; in two of them the injections were made intravenously (one with pure cultures and one with organ emulsion); in the other two intraperitoneal injections were given (one with pure culture and one with organ emulsion).

Before the experiment all of the animals were injected with tuberculin; in none of them was a positive reaction obtained.

Of the 33 animals, 7 perished in from five to 63 days after the inoculation with the perlsucht bacilli, from a number of different causes. Five of these animals showed some traces of the disease; the other two were entirely free from it.

The remainder of the 33 calves are still alive (August 10, 1904), and apparently in the best of health.

II. *Experiments concerning the Susceptibility of Native Bovines and of the Mixed Races to Human Tuberculosis*

The experiments were performed on 14 calves, of which 6 were Japanese, and 8 belonged to the mixed types. Eight of them were treated with pure cultures; 2 of them were given intravenous, 3 intraperitoneal, and 1 intratracheal injections; 2 were given inhalations; the other 6 were treated with an emulsion made of the organs of a man, whose death was due to miliary tuberculosis; the organs contained numerous fresh tubercle bacilli; 3 were infected intravenously, and 3 intraperitoneally.

The tuberculin reaction before the experiment was negative in all the instances.

Two of the native animals, having had pure cultures injected into the cervical vein, died after 30 days and 56 days. One of them developed high fever eight days after the injection, this persisting for some time; the animal died on the thirtieth day, with symptoms of general debility. The autopsy showed the apices of both lungs dark red, and moderate swelling of some of the glands of the thoracic cavity. The mucous membranes of the pharynx and larynx were inflamed; the neighborhood of the vocal cord was covered with mucus in which a small number of tubercle bacilli could be demonstrated.

The second animal developed considerable fever about the tenth day, which also lasted for a long time. After 40 days, conjunctivitis appeared in both eyes, this gradually becoming so violent as to destroy vision entirely; death resulted on the fifty-sixth day after the injection, and as in the case of the first animal, seemed to be due to weakness. The organs of the thorax and abdomen were found normal, excepting that the left lung contained a very small pea-sized tubercle, in which a few tubercle bacilli were demonstrable. None of the other organs contained anything abnormal.

In neither of these cases are we permitted to speak of infection, as in the first place, the duration of illness was too short, and in the second place, the tuberculous lesions so slight that they could be found only with difficulty, and it goes without saying that in the short time having elapsed between injection and death the tubercle bacilli introduced into the organism could still have been alive.

The rest of the calves, 12 in number, were killed after from 101 days to 327 days, but in no instance could a trace of tuberculosis be found.

The number of calves and heifers used for these experiments was altogether 71; of these 52 were purely native animals and 19 had descended from mixed races.

The tubercle bacilli from the pure cultures as well as from the tuberculous organs before being utilized for the experiments, had been inoculated into guinea-pigs to note whether or not their virulence was great enough. All of the guinea-pigs perished after the usual lapse of time of typical tuberculosis.

From the results mentioned, the following conclusions can be drawn :

(1) Human tuberculosis is as frequent in Japan as in the civilized countries of Europe and America.

(2) Primary intestinal tuberculosis is relatively common in adults and children, although cow's milk plays no rôle at all in the feeding of children.

(3) There are large districts in Japan, where, in spite of the existence of human tuberculosis, the cattle remain absolutely free from the disease. In these regions it is not customary to consume either meat or milk from bovines.

(4) This is very important proof for the fact that under ordinary conditions human tuberculosis is not infectious for bovines, as the opportunities for infection certainly cannot be lacking.

(5) Among Japanese in general very little cow's milk is used and especially is it employed but little for the dietary of children.

(6) Under natural conditions the native animals show but very little susceptibility for perlsucht. If large doses of perlsucht bacilli are inoculated into them either intravenously or intraperitoneally, they become tuberculous to a certain degree; they do not seem to be at all susceptible to subcutaneous infection.

(7) The imported and mixed race animals are very susceptible to perlsucht.

(8) Human tuberculosis is not infectious for native and mixed race animals.

Before concluding I would like to say a few words concerning the two opposing opinions of Koch and von Behring. As is well known, Koch, at the congress in July, 1901, at London, made the statement that human tuberculosis is absolutely different from bovine tuberculosis, a conclusion which he had come to after two years of experimentation on young heifers. Von Behring took issue with this statement at the Congress of Natural Scientists, at Kassel, in September of last year. Von Behring believes that the milk taken by nurslings (cow's milk) is the chief source for the development of tuberculosis. He also stated that human tuberculosis is identical with that of bovines.

The fact has already been mentioned that primary intestinal tuberculosis is quite frequent in Japan, even though the natives drink but very little cow's milk, and even though they employ it but very little for the nourishing of their children; if the mother's milk does not suffice, a wet nurse is instantly taken into the house. This clearly proves that human tuberculosis in Japan can only be transmitted from man to man. And from the fact that native Japanese cattle are free from tuberculosis, and also are so little susceptible to it as to make it almost impossible for natural infection to take place, we can conclude that bovine tuberculosis was imported into Japan only after the introduction of foreign cattle. These importations, however, began only about 30 years ago, while human tuberculosis has existed in Japan as long as we have chronicles. Of especial deciding importance for the statement that human tuberculosis is different from that of bovines is the following: If this were not the case, it would be impossible to find districts in which bovines are entirely free from tuberculosis, in spite of their close connection with tuberculous human beings, and who are constantly giving the domestic animals the opportunity to infect themselves.

On account of these reasons it is impossible to trace the tuberculous infection of man back to cow's milk respecting bovine tuberculosis, and therefore I must subscribe to the opinion of Koch and say that the danger of the conveyance of tuberculosis from man to man occupies first place. Concerning the views of von Behring in relation to the mode of infection, I must confess that by us in Japan the milk fed to nursing infants (cow's milk) cannot play a rôle in the contraction of tuberculosis.

SHORT PAPERS

Dr. Carlos T. Finlay, Sanitary Chief of the Cuban Government, presented an interesting paper to this Section on "The Leucocytes," with suggestions as to the rôle that may be assigned to them in connection with cell nutrition and immunization.

Dr. George Coromilas, of Athens, Greece, presented a paper to this Section upon the healing properties of sulfite of carbon, particularly in chronic maladies of the lungs, and the treatment of tuberculosis.

Professor Tessier, of the University of Lyons, France, presented a paper to this Section on "Some New Studies of the Pathology, Diagnosis, and Special Complications of the Abdominal Aorta."

SECTION D

THERAPEUTICS AND PHARMACOLOGY

SECTION D

THERAPEUTICS AND PHARMACOLOGY

(*Hall* 13, *September* 24, 3 *p. m.*)

CHAIRMAN: DR. HOBART A. HARE, Jefferson Medical College.
SPEAKERS: PROFESSOR OSCAR LIEBREICH, University of Berlin.
SIR LAUDER BRUNTON, F. R. S., London; D.C.L. Oxon.
SECRETARY: DR. H. B. FAVILL, Chicago, Ill.

THE RELATION OF THERAPEUTICS TO OTHER SCIENCES IN THE NINETEENTH CENTURY

BY OSCAR LIEBREICH

[**Oscar Liebreich,** Director of Pharmacological Institute, University of Berlin, since 1872. **b.** Königsberg, Germany, 1839. Studied Chemistry under Fresinius in Wiesbaden; studied Medicine in Königsberg, Tübingen, and Berlin; Assistant in Medicine, University of Berlin, 1867–68; Professor of Therapeutics, *ibid.* 1868–72. **Editor of** *Therapeutic Monthly; Encyclopedia of Therapeutics; Kompendium der Arzneiverordung.*]

EVERY political historian will prefer to trace the development of a period of history from one distinct event. A chronological introduction cannot be of such importance to him as an historical survey, in which events of great moment form the basis of a new development.

What is true of political evolution applies also to the growth of every branch of natural science and medicine. The first year of a century, though filling men with joyful confidence and new hopes, has not the same attraction for the investigator; and yet, in order to obtain a general view of the growth of the different branches, it is desirable not to lose sight of this idea, but to consider all the stages of progress in common from a certain point of time, and thus the study of the history of therapeutics must also be subordinated to this aim.

Although the evolution of the nineteenth century has frequently been threatened by heavy political clouds, we have seen them often pierced by the sun of progressive science, which, especially in that century, has called forth a fertility of culture such as has scarcely been witnessed in any previous period of one hundred years. The past century more than any other has been distinguished by the multitude of newly discovered facts in natural science, as well as by the perfection and extension of the ideas of great discoverers of the previous century.

It is the age in which the greatest progress in natural science has been made. The vast numbers of new discoveries in medicine have lessened, or even almost suppressed, on the part of many persons, the feelings of admiration for each new acquisition.

The new phenomena and experiences which confront us on all sides surpass the wildest dreams described in former centuries as the eccentricities of fanciful minds. The abundance of material compels our admiration and allows the astonished eye no time to gaze long at one occurrence, for new impressions already crowd it out.

The nineteenth century has spoiled us; our demands for new acquisitions increase, and we grow impatient to know more. In this unsettled state the laborious work of the individual often seems lost, but the true scholar is buoyed up by the gratifying knowledge that mighty buildings can only be constructed of a mosaic made up of single stones. Yet, truly, humanity often settles down in a new building without admiring either the work of the architect or his material.

Moreover, the capability of enjoying nature and whatever we have added to our knowledge of the universe by laborious experiments does not appear to be a natural gift of man. Only education and culture can awaken the enjoyment of what is and of what is about to be. Mighty natural phenomena, indeed, fill the casual onlooker with admiration, but the observation of what is harmonious in nature, and the capacity of assimilating it for our own culture, can be gained only through education. This also holds good of art, and it is even more difficult in science. Since the uneducated majority is often inclined to pass by the greatest events with indifference, the nineteenth century has spared no pains to inform humanity of all the great innovations, to educate them, and thus to gain friends for the progress of civilization. This, indeed, is the object of your Congress.

There are various ways in which therapeutics (and it is here chiefly a question of pharmacodynamic therapeutics, that is such as concerns itself not with mechanical means but with chemical-physical processes) may develop.

New knowledge of the conditions of life of the organism often lead to remarkable discoveries in therapeutics. Thus physiology, especially the functions of the different organs, is of the highest importance for the progress of therapeutics.

A striking example of this is furnished by digitalis. Originally this plant was simply a popular remedy, which, like many substances in use among the people, proved efficacious in the case of many diseases, while, of course, of no avail in others.

When William Withering, in 1785, undertook a careful examination of digitalis, it was used for phthisis, dropsy, and scrofula, it is true, and its power of slowing the pulse was known, but was not utilized therapeutically. A proof of how little significance was attached to these purely clinical experiments may be found in the changes as to the admission of digitalis to the London Pharmacopeia. In the year 1721 it was included; in 1746 rejected, and not reaccepted until 1778.

Now in the year 1846, Weber made the surprising discovery that the vagus nerve has an inhibitory influence upon the heart, *i. e.*, that exciting this nerve causes slower pulsation, and that cutting it occasions extreme acceleration of the action of the heart. This decisive experiment formed the basis of Traube's clinical investigations, and he was able to prove that the effect of digitalis on the heart corresponded to the excitation or section of the vagus nerve. This fact has been utilized clinically in diseases of the heart, arteriosclerosis, and dropsy,— and now upon a firm basis,— so that digitalis has emerged from its former position of uncertainty and taken a place among the efficient and reliable remedies, and we can safely say that it will not again disappear from the pharmacopeia, at any rate not owing to any uncertainty as to its effect.

Such investigations have now been undertaken with a number of other preparations, and on a large scale, such as, for instance, the clinical researches of Sir Lauder Brunton on "casca" (erythrophleum) and of Sir J. T. Fraser on Strophanthus hispidus, a plant similar to digitalis, but differing in its effect on the vaso-motor system, and which was also soon adopted in therapeutics. Much the same may be said of atropine, which chiefly through the knowledge of its physiological effect on the iris, on the non-striated muscular system and the glandular secretions, affords us an exact indication of its scope of utility in disease.

Thus we have here a source of fresh observations. Often the functions of the organism are affected in an isolated manner that we should scarcely have thought possible, for instance, by yohimbin.

This physiological method is applicable to all chemical bodies, and the progress in our knowledge of curative powers depends solely on the progress of experimental physiology.

The physiological action, however, does not always remain within the limits of what is normal, for it may sometimes become pathological. This was remarked by various scientists as early as the middle of the eighteenth century, and shortly before the beginning of the nineteenth century (1799) A. Fr. Hecker expressed this view in his *Physiologia Pathologica, i. e.*, in "the theory of the composition and functions of the human body and its different parts in an abnormal condition."

How differently we may view physiologically active bodies can best be seen in the blood. But here, too, we observe that a rational system of therapeutics only became possible in the nineteenth century after a knowledge of the physiological effects had been gained. Berzelius was the first to recognize the presence of iron in the blood. The discovery of a ferruginous coloring-matter of the blood, hemoglobin, did not follow until much later. It is true that in 1854 Wöhler declared globulin and hematin to be contained in the blood corpuscles. But Funke (1852) and Lehmann (1853) had already established the fact that the coloring-matter of the blood, hemoglobin, is a distinct crystallizable substance which is capable of absorbing and giving off oxygen. Hemoglobin, we may say, is, to a certain extent, the quintessence of the respiratory activity. This function may be destroyed by inhaling carbonic oxide which enters into so close a combination with the coloring-matter of the blood that its respiratory function ceases. Thus blood in such a state is a menace to life which cannot be obviated by any drug, but we are able since the respiratory function of the blood has been understood to avert this danger in most cases by removing the poisoned blood and transfusing fresh blood.

The greatest hopes for the further development of therapeutics are raised by the fact that chemical substances are capable of restoring pathologico-physiological processes to a normal state. Here we may cite the antipyretics, which are able in the most striking manner to reduce to the normal state a rise of temperature, that is, a febrile phenomenon.

The drugs just mentioned are therefore of great importance in therapeutics as symptomatic remedies. Of course, they are in no way able to destroy the cause of disease, but merely alleviate or avert injurious symptoms. For the physician, however, this very quality is of paramount importance in the majority of cases. The cause of disease may disappear through the spontaneous healing process of the organism, while the symptoms are removed, which, had they been left alone, would inevitably have led to the death of the patient. Yes, we may say that it is one of the greatest aims of therapeutics to treat disease symptomatically, for we must endeavor to ease the sufferings of humanity, and the great advantage of this method of healing becomes specially evident when the cause of sickness cannot be destroyed by any remedy hitherto known. This may best be demonstrated in the treatment of poisoning. If, for instance, through a mistake, or for any other reason, a deadly dose of strychnine enter the system, the sufferer will expire under the symptoms of suffocation, caused by the convulsive contraction of the respiratory muscles. As, however, we are enabled to arrest this spasmodic contraction by means of chloroform, chloral hydrate, and other drugs, we can thus give the system time to eliminate the strychnine causing the illness. This being entirely thrown off, the morbid phenomena also disappear, and complete recovery soon ensues. It is possible, though as yet unknown, that purely symptomatic remedies may also influence the cause of disease.

At the beginning of the nineteenth century, chemistry was still of little service to the science of medicine. True, Lavoisier's greatest discovery in regard to metabolism in the organism was known, that is, that the oxygen of the air causes combustion, and when inhaled accomplishes the same object in the system. This must have given medical men an entirely new perception of the processes of life, but the time had not yet arrived for experimental work on this subject.

Even at that time numerous elements were known, 30 in number, whereas at the end of the century 76 elements had been found. A number of these elements were made use of in therapeutics in a pure state or in combination, without our being able to base their application upon rational, theoretical hypotheses, as, for instance, in the case of iron and its compounds, the use of which extends to the remotest times. On the other hand, there were among them elements employed as drugs, such as antimony, which first came into use in the Middle Ages, and which may be cited less as a proof of the therapeutic value of this matalloid than of the antiquated prejudice of a French faculty which absolutely refused to acknowledge any "drug," owing to its predilection for blood-letting. The rage of dogmatic physicians may be recognized in the words of the anathema against Torpet (cf. O. Liebreich, *Die historische Entwicklung der Heilmittellehre,* Lecture, Berlin, 1887).

On the other hand, the science of therapeutics placed great hopes in the isolation of alkaloids, which marked the beginning of the century. This era began with the recognition of the importance of morphia by Sertürner in the year 1804. Then followed the discovery of nicotine by Vauquelin in 1809, quinine in 1811, cinchonine in 1820, and of strychnine in 1818. This, at any rate, suggested the method of obtaining from extracts, frequently incumbered by useless matters, the active principle, and making it available for therapeutics, and hence a certain practical utility must even nowadays be accorded to pharmaceutical chemistry.

As regards a knowledge of the mode of action, however, the problem not only lies in the chemical composition and recognition of the substance employed, but also in the chemism of the organism. Outside the organism it is a lifeless substance, but in the system it is not only the substance itself but its metabolism and manner of action which must be taken into consideration. The theory of metabolism can only be of decisive value for therapeutics when not only the properties of the drug applied but also the chemical action of the organism are so far known as to enable us to judge of their mutual effect. For this reason, of course, a knowledge of the chemistry of the human system is of the greatest importance. Just a year previous to the beginning of the nineteenth century the urea which appears in well-formed crystals in the human organism was discovered by Fourcroy and Vauquelin. This fact, certainly, did not appear so strange, since crystalline matters had already been obtained from plants, but even in the beginning of the century the idea was still firmly rooted in the mind of the naturalist that these substances could only appear as the products of vital energy. This presented itself to the minds of men of that time as an entirely distinct force, which, independent of physical and chemical laws, manifested itself in a characteristic form in the organism. There is no discovery which has so often been quoted in the interest of the medical and other biological sciences as the observations of the chemist Wöhler who, in 1828, observed the formation of urea in a substance obtained outside of the system, namely, ammonium cyanide, by the transposition of atoms. But if we rightly consider this grand discovery, which completely refuted the followers of the theory of vital energy, it would still, perhaps, be possible, in spite of this discovery, to undertake the defense of the theory of vital energy as something beyond the laws of natural science, for neither Wöhler's synthesis nor the manner of formation of urea from carbonyl chloride and ammonia, or from ethyl carbonate and ammonia, or from cyanamide by hydration, or from ammonium carbonate, as well as from leucine and from other substances of the organism, gives any actual explanation of the formation of urea in the system. The synthetic product is identical with the product of the organism, but the synthesis, or rather the formation of urea in the body takes place in accordance with laws, the exact nature of which we do not fully know even at the present day. This is, indeed, the case with a large number of other substances derived from animals or plants. Although the chemical constitution of substances was constantly more and more exactly defined in the course of the nineteenth century, the manner of formation in the organism still remains hidden from us. We frequently find it stated that we must not simply compare the processes of the organism to the test-tube experiment of the chemist. There is no doubt that processes of metabolism take place within the body for which the synthesis performed outside of the organism gives no explanation. From my somewhat dissentient attitude in regard to the conclusions drawn from Wöhler's experiment, I might for a moment be thought to favor the view that the activity of the organism in the form of vital energy is beyond the laws of natural science, but that is not the case. Even if in synthetic experiments other means are employed than are available within the organism. the supposition is justified by the possibility of synthesis, that the organic processes occur in accordance with purely physical and chemical laws, but that other conditions not present in test-tube experiments also play a part.

Here we must turn for a new mode of thought to Schwann's magnificent discovery of the animal cell. Through it the anatomical conception of the organism was placed upon an entirely different basis. As human tissues consist of cells, and the entire development of man results through cell activity, this must naturally lead us to assume that the purely chemical part of human existence takes place in as many cells as the individual possesses. That which in chemistry we describe as a reaction must, if we leave out of the question the chemical processes in the digestive tract, take place in small separate spaces, such as the chemist never employs for his experiments. The chemist does not usually assume that reactions occurring in such exceedingly restricted spaces differ from those which take place in the vessels used for his operations. It will be the task of the biologist to investigate whether this chemical action in the cells undergoes any modification through limitation of space.

I have been able to prove in the course of investigations on the "dead space in chemical reactions outside the organism" that powerful phenomena of friction take place here. This could not be definitely proven experimentally in the case of all reactions, but sometimes it could be shown that if the space inclosing the fluid be diminished, the reactions in comparison with those which occur in larger spaces are retarded if not completely arrested. The objection might be raised that in these experiments the retardation or arrest of reaction was generally due to the nearness of solid walls, but it was observed that the same phenomenon is noticed when the boundary of the fluid is only formed by surface tension, for the tense surface behaves like a firm elastic membrane toward the fluid, as is the case with many cells. The results showed that whenever the friction of the liquid increased, the chemical reaction was retarded. This hindrance of the reaction in small spaces, which differs in the case of different reactions, naturally permits the conclusion that, contrary to what happens in large spaces, in small ones entirely different reactions will result. Of course, this observation can only serve as the initial proof that the chemical action in the cells is unlike that which occurs in test-tube experiments. We see that here also the argument for the acceptance of the theory of vital energy which I pointed out to you as possible, is refuted.

As regards drugs and their absorption these chemical processes probably play an important part, for we observe that reactions occurring outside of the organisms do not take place within it, and on the other hand, combinations arise which are difficult to produce externally. Here we may mention, by way of illustration, the facility of decomposition of common salt into hydrochloric acid and alkali.

Moreover, I should like to remind you that, for example, in the toxicological processes in poisoning with carbolic acid we were entirely unable to foresee that the sulphuric acid of the organism forms with the carbolic acid a complex sulphuric acid, which, being non-poisonous, arrests the toxic effects of the carbolic acid.

Starting from this consideration, it does not appear strange that a number of substances which, even when much diluted, have a destructive effect on bacteria, manifest when taken up into the system no trace of disinfecting power, such as, for instance, phenol itself and corrosive sublimate in cases of anthrax.

The simplest example that the discovery of the cause of disease is by no means decisive in therapeutics may be seen in the development of the trichina. It is a humiliating fact that we are entirely powerless against this enemy. Even the female trichinae developing in the intestine after the consumption of meat infected with these parasites cannot be made innocuous by any known anthelmintic, and we are not even able to expel these intestinal trichinae by means of purgatives. The embryos wander irrevocably into the muscular tissues to destroy the organism, or by encapsulation remain permanently in the man or animal. Even in this process of calcification of the trichinae we are quite powerless to intervene.

The nineteenth century has been distinguished by the discovery of the causes of disease. But this does not give us means of "curing." As the history of therapeutics, however, shows that in the case of serious maladies, such as syphilis and malaria, the remedies have been found long before the recognition of their cause, we must continue to search for remedies independently of the causes of disease. So far the knowledge of morbific agents has been more important for prevention than for cure.

On the other hand, remedies like iodoform are entirely ineffective on bacteria outside the system, whereas after the entrance of this substance into the cells an energetic force is opposed to the invaders. As in every observation we must be careful not to draw too far-reaching conclusions, because the possibility of reactions taking place outside of the organism may also hold good within it, as, for instance, in the treatment of lead-poisoning. Therapeutics, thanks to Melsens, celebrated a great triumph here, for the iodine of the iodide of potassium administered in this disease combines with the lead united to the albumen molecules, forming iodide of lead, and can then leave the body dissolved in the alkaline juices of the organism, and thus bring about a cure.

It may be said, in passing, that in the case of many active substances specific chemical processes take place as are, for instance, seen in phosphorus poisoning. Phosphorus, though usually so easily oxidized, when absorbed, is not oxidized quickly enough by the oxygen of the cells; in the presence of turpentine oil, however, a transference of the oxygen occurs, and the phosphorus is more rapidly oxidized, combines with the oil of turpentine, and, as we must assume, forms turpentine-phosphoric acid, which is innocuous to the system. By the ingestion of oil of turpentine the organism can thus overcome the cause of illness.

Unfortunately we do not possess similar remedies for some other toxic morbific agents which are taken up by the cell.

Since for the progress of therapeutics it is necessary to consider the chemical and physical qualities of the body, therapeutics is naturally dependent upon progress in chemistry. Although, as has already been shown, pharmaceutical chemistry can be utilized for the benefit of medicine, the results of theoretical chemistry have not as yet become of much distinct importance for therapeutics. In the first half of the nineteenth century distinguished chemists occupied themselves with the laws of matter independent of biological processes. Various chemical and physical theories followed each other, and the theories propounded by Dumas, Gerhard, Williamson, and Kekulé eventually developed into van 't Hoff's stereochemistry, and in the physio-chemical researches. But these discoveries, though made outside the limits of biology, came to be of great importance to medicine when medical chemistry, fostered both by chemists and physicians, began its growth.

In the beginning of the century theoretical views in regard to drugs had to contend in part with the philosophical tendencies of those times, in part with the ill success which formerly attended the iatro-chemical and physio-chemical schools of physicians. Progress in the application of therapeutical measures was left to pure empiricism, and the view was accepted that what applied to food would also do for medicine; for we became acquainted with the use of coffee, tea, chocolate, potatoes, etc., not through theory, but simply through empiricism. This standpoint could be justified all the more because many important remedies, such as quinine, arsenic, and Peruvian balsam (which last substance has almost led to the disappearance of a contagious disease similar to leprosy in its terrible forms) became available to humanity purely through empiricism and not as the result of scientific investigations. Similarly, balneotherapy is of empiric origin; only recently, owing to the physiological researches of Winternitz and others and the application of physical chemistry, has it assumed the dignity of a separate branch of science. In consequence of a false point of view and empiricism the creative ideas of a Paracelsus were forgotten.

The progress in the chemistry of organic substances offered an opportunity to combine chemical and medical research, especially in the province of therapeutics.

I myself have had the pleasure of seeing that by this coöperation of medicine with organic chemistry an impulse has been given to therapeutics, which, in spite of a certain opposition, cannot again disappear from the sphere of research, an opinion which was held and expressed on the part of chemistry by the late A. W. von Hoffmann.

A good example is furnished by chloral, a drug formerly belonging to the chemical rarities, because Liebig's method of production provided no means of obtaining sufficient quantities for experimental medical research. This body was known as a chemical substance as early as 1832; but its intrinsic, therapeutic value was not discovered until the year 1868. It is in America more than anywhere else that these investigations have received the fullest appreciation. The use of chloral hydrate was based upon the idea that when taken up into the blood a splitting-off of chloroform takes place, as is the case outside the organism in the presence of all alkalies. This point has been the subject of much controversy. There can be absolutely no doubt that whenever chloral has had no soporific effect, a considerable quantity of urochloralic acid can be found in the urine, which must be traced back to the chloral. It is equally certain, however, that small quantities of urochloralic acid always are to be found in the urine after the administration of chloral. But it is just as true that the main therapeutic effect depends on the formation of chloroform. Only those who consider these principles will, as is shown by clinical experience, be able to observe chloral in the full unfolding of its effect. Shortly after its effect had become known the Glasgow clinician, Russel, proved that in conditions of excitement in typhoid fever, owing to the marked increase of the alkalinity of the tissues, small doses of chloral hydrate through their decomposition manifest the same effect as that produced only by large doses in similar conditions in other diseases. On the other hand, in gout the opposite happens. Even large doses do not produce the desired effect, since alkali is lacking for the decomposition.

But we cannot judge of all organic bodies from the standpoint of decomposition. Many take up substances from the organism, and since the discovery that benzoic acid becomes hippuric acid, and salicylic acid changes to salicyluric acid, it has been proved that the opposite of decomposition takes place with a number of drugs. Furthermore, it does not seem impossible that many substances unite with the disease-products formed in the organism. This hypothesis may be supported by the fact that the system itself produces an acid, such as glycuronic acid, which carries off foreign substances from the organism, such as camphor, phenol, etc., in the form of a double combination.

Since the time that chloral came into use, organic bodies have been particularly investigated. Owing to the tremendous amount of material, there has been a tendency to place reliance upon the chemical composition in making a choice, and it has been assumed that the chemical constitution stands in a certain relation to the action of a drug. Many experiments have been made in this direction. We do not wish to deny that such an influence occasionally exists; at any rate, we see that when the action of a given substance is known, changes in the molecule will produce a difference in action, and that by the introduction of certain groups certain definite changes in the effect may be expected. Among this group of bodies is antipyrin, in which changes in the side-chains leave the nature of the effect pretty much the same, even though new therapeutic advantages are obtained, as is best seen in pyramidon. A similar example is offered by veronal, lately suggested by E. Fischer as a soporific.

But it is as yet impossible to predict the effect of a chemical body from its constitution, unless a decomposition product of known action is formed, as in the case of chloral hydrate, or unless an active and well-known nucleus forms the basis of the substance. There are, of course, examples which point to the connection between constitution and effect, such as the difference between the action of bi- and trichlorinated aliphatic combinations. The trichlorinated bodies have a lethal influence on the heart; the bichlorinated bodies, such as chloride of ethyliden, only on the medulla oblongata. If trichlorinated butylaldehyde (butylchloral) be administered to an animal only an effect on the medulla oblongata is produced, in spite of the triple chlorination. The reason of this is that allylchloroform is formed in the organism, which, not being stable, splits up into dichlorallylen, which is a bichlorinated body.

Owing to the progress in chemistry medical science has been enabled to determine the relation which certain new drugs, by reason of their composition, bear to other established remedies of known constitution. This has been demonstrated by Gaetano Vinci in eucain, whose composition is analogous to that of cocain. Eucain is a drug which is truly fitted to replace cocain on account of its slighter poisonous nature, especially in the form of its lactic acid salt.

It has frequently been assumed that certain atomic groups in the molecule are the bearers of a special action, and that accordingly the bodies of a chemical series must exhibit a similar effect. That is, however, by no means the case, for even formic acid and acetic acid manifest markedly different biological properties. In alcohols the theory is founded on the presence of a certain chemical group, which is spoken of as the alcohol group. But we see this group appearing threefold in glycerine, and yet no physiological connection between the effect of common alcohol and of glycerine can be established.

In general we must confess, however, that we cannot as yet speak of a relation between constitution and effect, because what we call effect must be regarded as an influence on the different functions. Even if we consider the apparently simple mechanism of sleep, we must remember that it may be induced by an influence on the brain, or equally well by an action on the periphery. We cannot here enter into a physiological analysis of the processes taking place in the organism, but, as the above example shows, the most diverse parts of the system may be affected, so as to produce a similar result. Moreover, the different hypnotics, although fulfilling the same purpose, have an entirely different composition. On the other hand, when investigating the action of chemical substances we may always expect new results to become manifest by chance, for when Baumann was studying the effects of sulfonal it had never occurred to him that this body might possess soporific powers. We can best see the prominent part played here by chance in the introduction of salicylic acid into therapeutics. After Kolbe had succeeded in synthetically producing this acid, which is normally contained in the bark of the willow, he thought that it would exhibit disinfecting properties within the system by its decomposition. This decomposition does not, however, occur. Yet Kolbe's idea has led to the clinical application of this substance, and the valuable results obtained by Stricker from the use of salicylic acid in acute articular rheumatism, although it is not by any means a specific, have stimulated to continuous researches, most fertile for therapeutics, upon the various salicylic preparations.

It is not impossible that, starting from this small therapeutic field, the indications for the use of salicylic preparations may be greatly extended.

Even though the constitution of a chemical body gives us no firm basis for pharmacodynamic investigations, we can yet derive the most varied hypotheses from it. In pharmacodynamic research we may uphold the same principle which Claude Berhard expresses, namely, that by promulgating an hypothesis we are led on to experimental research, the solution of which may be of the greatest importance. G. Gore expresses his opinion in much the same way:

"A discoverer is a tester of scientific ideas; he must not only be able to imagine likely hypotheses, and to select suitable ones for investigation, but, as hypotheses may be true or untrue, he must also be competent to invent appropriate experiments for testing them, and to devise the requisite apparatus and arrangements."

The science of therapeutics quite properly does not follow a one-sided course, but seeks aid in all directions, and since the results of the exact natural sciences are not yet ripe to guide us clearly, we must take into consideration what has been gained by practical experience, for it would be a false principle to condemn popular medicines without examination. At the beginning of this lecture the successful application of digitalis was already mentioned.

And here we must not entirely neglect the historical side of empiric observation. Frequently even the most absurd practices are based upon theory. When we turn away in disgust from the unclean excretory products of animals used in ancient times and by Asiatic nations, which we now regard as the very outcome of folly, we cannot ignore the fact that even this practice was founded on theory, though a false one. This is proved by Pliny, who tells us that animals eat and digest plants, but the medicinal part is not absorbed by the organism, but excreted, for which reason the feces contain substances curing human ills. These prejudices remained for centuries, as is proved by Paulini's book, published in 1697, but which can now be read only with disgust.

Such excretions as musk and castoreum, which are undoubtedly of value, should by no means be rejected. But particularly the nineteenth century has directed attention to the question whether the products of the organs themselves, or certain substances contained therein, might not be employed as remedies.

It was no easy task for Brown-Sequard to prove that the principles contained in the testicles of animals exercise a stimulating and exciting influence on the system. The discovery of spermin crystals, their occurrence in various organs, and the decidedly stimulating effect produced by these substances, reminded physicians that creatin, which had already been obtained from meat extract, had an effect similar to that produced by the salts of potassium on the animal body. This, as we may say, weak connecting link yet led to the further development of a principle in therapeutics. Medical chemistry has already succeeded in obtaining from the organism substances which may be of the greatest importance for therapeutics. You all know the effect of thyreoidin on the system. Obviously the active principles here are albuminoid bodies, the peculiarity of which has already been partly explained by Baumann in that iodine is one of their component parts. Probably no one would have imagined that this element must be regarded as one of the constituents of the human organism.

The very much studied question of the constitution of albumen will naturally lead to a more exact knowledge of the different kinds of albumen which are of value therapeutically and open a new field of observation to pharmacology.

The most surprising feature in the action of substances of the organs is presented by the constituent of the supra-renal capsule, adrenalin, not an albuminoid body, it is true. In order to better illustrate the importance of the new domain, the following pharmacodynamic experiment may be mentioned. Doses of cocain which are absolutely fatal to animals are easily borne in the presence of adrenalin without any injurious effect whatsoever. These substances, as they are found in the body of animals, are certainly of importance for the life-processes themselves. Taken from the animal body, they have the same effect as the human product, and can thus be employed as curative agents in man.

But medical chemistry had already undertaken researches which were not indeed utilized therapeutically at once, but came to exert great influence on therapeutics. In 1869, Zuelzer and Sonnenschein proved that alkaloidal bodies may be formed by the decomposition of the organic substances of the organism, and later on the theory of toxins was derived from this observation. This again has led to von Behring's remarkable and far-reaching theory of the anti-bodies formed in the organism.

How to make the substances obtained from the bodies of animals useful for therapeutics, depends upon the state of our physiological and chemical knowledge, and especially on the train of ideas arising in connection with these subjects. This can be seen, for example, in the case of the esters of cholesterin, the composition of which was already discovered by Berthelot, but not in connection with biological investigations. On the other hand, cholesterin esters had been observed in the form of wool-fat, and the impure product was used medically and cosmetically even in ancient times for its curative powers. It was proved that a functional significance as regards the animal organism must be attributed to cholesterin esters, for they are present in mammals, birds, and all creatures whose external surface is of keratinous character. They give luster to the skin, but act chiefly, so to say, as a protective varnish. The white substance of new-born children is therefore very properly termed cheesy varnish (vernix caseosa). It was formerly thought to consist of glycerine fat, but it is actually composed of cholesterin esters. The higher members of these esters are characterized by the physiological properties of wax. Gottstein has shown that this substance offers no food for microbes, is very stable, difficult to saponify, and not decomposed by the oxygen of the air' as are other fats. Thus it forms a protective matter, especially effective by reason of its waxy nature, and this has led to the production and application of therapeutic substances similar to cholesterin ester, as, for example, fetron.

The influence of pathological anatomy on therapeutics belongs entirely to the nineteenth century. To John Hunter in England and Bichat in France belongs the credit of freeing pathological anatomy from the brainless descriptive scientists, and of forming it into the necessary basis for every form of progress in therapeutics. From this time until Virchow's labors, the decisive importance of which is recognized impartially by all nations, pathological anatomy has exercised a great influence upon medical activity. Cellular pathology especially, in spite of all former battles and present attacks, will form the basis of every experimental and therapeutic observation, though some of the views concerning it may undergo modification through the progress of science, and opinions which Virchow himself could not accept may be brought forward again. The scientific question which appeared as a result of cellular pathology is the question of the cause and symptomatology of disease. Nothing can be more suitable in treating this question than to quote Virchow's own words:

"An elementary pathological process in the sense of cellular pathology appears thus: an external influence acts upon a living cell and alters it in a mechanical or chemical way. The external influence is the *causa externa*, or as we simply express it, *the cause of disease:* the altered condition is called *passio*, disease. If now, in consequence of the change undergone, an action (*actio s. reactio*) takes place in the living cell, this change is called a *state or irritation* (*irritamentum*), and the cause of disease irritants. If, on the other hand, no action ensues, if the condition is limited to the change "suffered" by the cell, we have to do with a mere disturbance (*laesio*) or *paralysis*. Since, however, the same cause can evoke irritation in one cell, merely a disturbance in another, and even paralysis in a third, we assume a certain difference of the internal arrangement to be the cause of this varying behavior. Thus we come to the internal cause or predisposition."

But these words, spoken in 1880, must be modified according to present experience. According to Virchow the *causa externa* is the cause of disease. The irritant acting upon the organism is *under all circumstances* the morbific factor according to this assumption. We do not wish to play with words. If, indeed, this foreign intruding agent produces a destruction of the cell-power or a morbid modification of it, it obviously must be regarded as the actual cause of disease. But when, for instance, we see that the invading body produces only an entirely local irritation, or, although capable of reproduction, as is the case with bacteria, no proliferation occurs, it becomes difficult to consider the same factor as the cause of disease in all instances. Virchow terms this phenomenon of indolence of the cell towards the intruder a want of predisposition; according to the school of bacteriologists, however, the cell is not a culture medium in the given case. We see from this explanation that Virchow himself assumes the cell-power to be variable, and we can quite logically and correctly say that by the term disease, *i. e.*, nosos, is designated that condition in which the external irritation can accomplish the defeat of the cell.

Von Hansemann has shown from a pathological and anatomical point of view that in cases of diabetes mellitus and other diseases the tubercle bacillus involves secondarily the lung. Von Hansemann calls this disposition, but we must certainly first of all term it "nosos," since it is a question of proved deviation from the normal.

This can also be illustrated by experiments. In a frog anthrax bacteria do not proliferate. As soon, however, as we place the animal in an incubator, *i. e.*, weaken the cell-power by heat, we are able to make the animal susceptible to the inoculation of anthrax. In this case the parasite is only a parasite of the diseased cell, and this kind of infection I have termed nosoparasitism. Thus we must describe as "nosos" the molecular change which we can no more observe through the microscope than we can the course of a chemical reaction, the outcome of which we judge only by the result.

The cell is subject to the same vital fluctuations as Brown has assumed for the organism. Brownonian theory has had no special value for practice, it is true, because at that time it was impossible to base a system of therapeutics on these observations so as to be of practical use. But it must be acknowledged that his theoretical deductions can be applied to the vitality of the cell. This theoretical explanation is under all circumstances of decisive importance for therapeutics, and already physicians are beginning to direct attention to this view in the study of therapeutics. Thus A. Menzer says: "The solution I have attempted to give to the question of the etiology of acute articular rheumatism is derived from the theory of a correctly interpreted nosoparasitism."

This question has grown to be of special importance for pulmonary phthisis. We cannot here enter into the subject of infection by tubercle bacilli; only one thing is certain, namely, that the bacillus is destroyed if the cells become healthy and only does harm when the cells are diseased. Even before the discovery of the tubercle bacillus this fact was proved by dietetic and open-air cures, as described in the excellent work of the two Doctors Williams, father and son, and Freund again has shown lately that the functions of the tissue of the lungs are impaired by abnormal immobilization of the first rib, and that then the tubercle bacillus can begin its work.

At the present day pharmacodynamics teaches that there are indeed drugs which do not merely act specifically upon a tissue, as phosphorus acts upon the formation of bone, but that there are also cell excitants, such as cantharidin, which, without themselves having any effect on the bacteria, can bring about the cure of diseased tissues, so that the nosoparasitic bacilli are destroyed.

But here begins a branch of science which, like the theory of immunity and serum therapy, occupied the end of the nineteenth century, and the waves of discussion still run so high that it is as yet unsuitable for an historical survey. It is sufficient to say that all the investigations of the present as well as of the past century afford us a guarantee that we are following the right road of progress in therapeutics, and assure us that in regard to the healing of disease there lie before us "infinite possibilities," to use the apt phrase which has been already employed in regard to the development of your country by Ludwig Max Goldberger, "Das Land der un-begrenzten Moeglichkeiten."

THE PROBLEMS OF THERAPEUTICS

BY SIR LAUDER BRUNTON

[Sir Lauder Brunton, Physician to St. Bartholomew's Hospital, London. b. 1844. M.D., Sc.D., LL.D. (Edinburgh); LL.D. (Aberdeen); F. R. C. P.; F. R. S. Author of *The Bible and Science; Text-Book of Pharmacology; Therapeutics and Materia Medica; Disorders of Digestion; Lectures on Action of Medicines; Disorders of Assimilation; Collected Papers on Circulation and Respiration;* and numerous papers in scientific and medical periodicals.]

The subject of my lecture to-day is "The Problems of Therapeutics." My audience is a select one of persons interested in science and art. But science in these days has branched out so widely that it is impossible for any single person to be acquainted with every department of it, so that the terms used by a zoölogist may be unintelligible to a mathematician, or *vice versa*. There are some here whose researches have led them far into abstruse departments of science and if they were speaking I should gladly welcome a few introductory words from them on the very rudiments of their science in order to help me to understand a disquisition on the more advanced parts of their subjects.

Judging others by myself, I think they may be glad if I do the same, and I must beg the indulgence of those acquainted with medical science and its branches if this lecture should seem to be unnecessarily rudimentary. By therapeutics we mean the methods of healing. In the great staircase of St. Bartholomew's Hospital in London there is a large picture by William Hogarth representing the Good Samaritan. The poor traveler is seated on the ground, the Good Samaritan is pouring oil and wine into his wounds, while close at hand is a dog busily engaged in licking a cut which he has received in the fray. Both dog and man are engaged in solving, as far as they can, two of the primary problems of therapeutics, viz.: (1) how to relieve pain, and (2) how to restore health. For disease is want of ease, and health is only one form of the word "whole," by which we mean that a thing is entire and neither cut, broken, nor cracked. The closure of wounds is one form of restoring "wholeness" or "health" to the body, but it is by no means the only one, for the vital organs lie below the surface, and it is with disturbances of their functions, even more than with external wounds, that therapeutics, or the science and art of healing, is chiefly occupied. As exemplified in the dog or in the Good Samaritan, therapeutics is simply an art. Certain things are done because they have been found to do good before and so they are repeated again and again, but neither the dog nor the Good Samaritan understands the reason why their procedure is useful. It is only when we learn the reason why that an art becomes converted into a science. Therapeutics in its primitive form is one of the simplest of all the arts and is practiced by animals as well as by man, but as a science it is one of the most complex and most difficult of all because it requires a knowledge of the functions of the body in health, or physiology; of their changes in disease, or pathology; of the action of drugs upon the body, or pharmacology; and of chemistry, physics, and other sciences on which physiology, pathology, and pharmacology are based. Finally it requires the practical power of recognizing from the symptoms (in any individual case) the nature of the pathological changes present and the ability to apply the right methods of treatment in order to counteract these changes and heal the patient. It is evident that such complex knowledge as this must be very difficult of attainment, yet nevertheless the change of therapeutics from an art into a science is progressing with considerable rapidity. In a text-book on the subject which I published eleven years ago, I mentioned the use of quinine in ague as the best example of the art of therapeutics whereby we could cure a disease of which we did not know the nature by a remedy whose curative action we did not understand. Since that time, however, we have learned that ague depends upon the presence of a foreign organism in the body and that the benefits obtained from quinine are due to its poisonous action upon this intruder. This malarial parasite is only one of the many minute organisms which mar or destroy the health of the human body. Minute organisms or microbes are most useful in their proper place and without them the world would be uninhabitable because they are the natural scavengers which produce putrefaction in dead plants and animals and thus bring about their return to dust, fitting them for new life instead of allowing them to incumber the ground. But not content with this function some of them proceed to invade living beings, attacking not only the weak but even the strong, and by growing and multiplying within them weaken or destroy their hosts.

One of the great problems of therapeutics, then, is to defend the body from attacks of microbes. This may be done either (*a*) by weakening or destroying the microbes themselves or (*b*) by increasing the power of the organism to resist them.

It is convenient to speak of the body as a whole when we are discussing its invasion by microbes, but we must not forget that the body, like a country, is composed of many parts. The interests of the different parts are by no means identical, and while they generally act together for the common good they may not always do so, and either by their sluggishness and inaction or by their mischievous activity may do harm instead of good to the body as a whole. What is requisite for health is an harmonious action of all the different parts of the body, or as St. Paul very well puts it, "And thus all the body framed and knit together through that which every joint supplieth, according to the working in due measure of each several part, maketh the increase of the body unto the building up of itself" (Ephes. IV, 16, Revised Version), so "that there should be no schism in the body and that the members should have the same care one for another." No doubt in their long wanderings together Luke the beloved physician discussed physiology largely to Paul, and his expression is so good that I introduce it now.

Just as the people of a country is composed of individuals, so the body is composed of numerous cells. The whole class of microbes consists of isolated cells which are like a nomad population, each individual complete in himself, and all ready to form a swarm for attack and invasion. The cells which compose the body, on the contrary, are mostly fixed, and differ from each other in structure and function, but ought all to act together for the common good, like civilized people. Each cell lives in the fluid which surrounds it, blood or tissue juice, from which it takes what it needs for its own nutriment and pours back the products of its tissue activity which may be partly waste and partly manufactured products of the utmost utility.

In order to have a complete comprehension of therapeutic problems it is necessary that we should know something about the life of the cell, because the life of the whole body depends upon that of the cells which compose it, and the cure of disease and the preservation of life depend on our power to influence cell-life. The processes of life are to a certain extent the same in the human body as a whole, in the cells which compose it, and in the smallest living organisms or microbes as they are termed. They all digest and assimilate food, they all breathe, and they all excrete waste products. A knowledge of the processes of life in man helps us to understand them in low organisms and *vice versa*. The use of pepsin and pancreatin in indigestion is so common that almost everybody knows that these substances have the power of dissolving meat and that pancreatin converts starch into sugar. Everybody knows that these are got from the stomach and pancreas of animals and that it is by similar substances formed in our own digestive canal that we are able to dissolve the food we eat and render it fit for absorption. It has recently been found that pancreatic juice, as poured out by the gland which secretes it, is very slightly active, but it is made active by another ferment secreted from the intestine which is called enterokinase. The pancreatic juice contains several ferments; that which acts upon meat is called trypsine and in its inactive state it is called trypsogen. The action of the enterokinase on the trypsogen may be compared to that of a man who opens the blade of a knife and renders an instrument previously inactive very active indeed. If trypsine were absorbed into the blood unchanged it might digest the tissues themselves and it must be rendered again inactive. This seems to be effected by certain substances present in the blood which have a so-called "anti" action upon the ferments and render them again inactive. But though the digestive ferments might do harm if present in the blood in an active form and in large quantity, yet it is probable that all the cells of the body digest the food which is brought to them by the blood and tissue juices and break up this food for their own use by ferments which they contain themselves. Thirty years ago I advanced this view and supported it by the fact that I was able to extract from muscle by glycerine a substance which decomposed sugar. This observation received but very little attention at the time, but recently German literature is full of papers which support my views and confirm my results, although their writers apparently are ignorant of my work. Fifteen years ago, along with Dr. Macfadyen, I showed that bacteria not only excrete ferments by which the soil in which they are growing is digested, but that they are able to modify these ferments in accordance with the soil so as to digest either proteid matter or sugar. Curiously enough, within the last few years the pancreas in animals has been shown by Professor Pawlow to have similar powers.

No individual microbe has received so much attention as the yeast plant and no poison which is formed by any of them has done so much harm as the toxin or poisonous substance produced by yeast, for this toxin is alcohol, whose poisonous action has given rise to the term intoxication. The yeast-plant, when grown in sugar, excretes into it a ferment, invertase, which splits up ordinary cane-sugar or saccharose into two other sugars, dextrose and levulose. The yeast-plant may be separated from the solution of sugar by filtration, but the ferment which is already excreted will remain in the filtrate and may still continue to act on the sugar, just as pepsin may dissolve a piece of meat in a jar although the pig which produced it is dead and gone. But no alcohol will be formed by this excreted ferment. Alcohol is produced by something contained within the body of the yeast itself and its production was formerly supposed to be due to so-called vital action. It has now, I think, been proved that alcohol is produced by the action of a ferment which is contained within the body of the yeast-cell and is not excreted from it, so long as the cell is intact, but only passes out after the cells have been crushed into fragments. Whilst the cell is alive and intact it absorbs the sugar into its interior, breaks it up there, and forms the alcohol which is afterward excreted.

To make this clearer I may perhaps be allowed to use a very crude illustration and compare the ferment which is excreted by a bacillus or by yeast to the saliva which is said to be poured out by a boa-constrictor over its victim to facilitate its ingestion, while the ferments within the microbe may be likened to those in the stomach and intestine of the boa by which it effects the digestion of its prey.

Other microbes in like manner absorb nutriment and may form and excrete toxins, though both the nutriment and the toxins of bacilli in general differ from those of yeast.

To recapitulate what I have already said, we see therefore that

(1) Cells excrete ferments;

(2) They excrete poisons formed within their bodies; and

(3) When they are broken up they may liberate other ferments.

The ferments excreted by microbes apparently prepare the substance in or on which they are growing for assimilation, and the ferments within the cell-body decompose it further in the process of growth. It is probable that all cells, whether they be wandering microbes or cells coördinated in an organism, prepare and assimilate their nutriment by means of ferments, and Macfadyen and I found that not only have bacilli the power of excreting ferments, but apparently they are able to adapt the ferment which they excrete to the soil in which they are growing in much the same way as Pawlow has recently shown that the pancreas in animals modifies the ferments it forms according to the food which it is required to digest

Not only is digestion carried on in the stomach and intestines by the ferments which are now so well known even to the general public, pepsin, pancreatin, etc., which dissolve the ingested food so that it is readily absorbed into the circulation and carried to every part of the body, but the other cells which compose the various parts of the body, muscles, nerves, and glands, probably carry on the functions of their life by means of ferments also. By means of these they alter and assimilate the various substances which are brought to them by the blood and juices of the body, and after having supplied their own wants they throw into the circulation the altered residue of their pabulum as well as the substances which they have themselves formed in their processes of growth. They probably repeat in fact what we have already seen to occur with yeast, which not only alters the sugar in which it grows by a ferment which it excretes, but also produces carbonic acid and alcohol by means of a ferment which remains within the yeast-cells so long as these are intact and only becomes liberated when these cells are broken up.

An excessive quantity of their own products is usually injurious to cells and too much alcohol will stop the growth of yeast. At the same time these products are frequently very nutritious for cells of a different sort and alcohol furnishes a most suitable pabulum for the organisms which produce vinegar. Vinegar in its turn is toxic to the microbe which produces it, but serves again as a soil for another which gives rise to a viscous fermentation. By the successive action of these ferments a solution of sugar may produce, first, alcohol, secondly, vinegar, and thirdly, ropy mucus. In this particular series each microbe produces a substance injurious to itself but useful to its successor. This is, however, not always the case because a cell may produce a substance not only injurious to itself but injurious to other cell, and alcohol in large quantity not only kills the cells of yeast but kills other cells as well. Similar conditions occur within living organisms where the cells composing the different parts are connected together and pass on the products of their life from one cell to another by means of the circulation of the blood and tissue juices. The secretions of one part may be, and indeed generally are, useful to other parts of the organism and so long as no part sins either by deficiency or excessive action the whole organism maintains a condition of health. But this is not always the case and health may be destroyed by (*a*) excessive, (*b*) defective, or (*c*) perverted action of one or more of the parts composing the body.

But health is even more frequently destroyed by the invasions of organisms from without. When these organisms fall upon an open wound they tend to grow and multiply rapidly, they secrete ferments and form poisons which enable them to destroy the tissues upon which they have fallen, and then finding their way into the circulation and being carried to all parts of the body they kill the animal which they have attacked.

One of the great problems of therapeutics then is to discover how best to defend ourselves against the attacks of microbes. In Hogarth's picture we see two methods by which this is done. The dog licks the wound it has received and thus removes from it any pathogenic organisms which may have lighted upon it. By insuring their absence it renders the wound *aseptic*, and *asepsis*, which is another word for excessive cleanliness insuring the absence of organisms, is one of the great measures by which the triumphs of modern surgery have been achieved. The treatment applied by the Good Samaritan to the wounds of the traveler is somewhat different, for he pours in wine the alcohol of which may hinder the germination of any microbes on the wound and thus prevent them from producing sepsis. This method, which in the hands of Lister has revolutionized surgery, is termed *antiseptic* as distinguished from the *aseptic* method used by the dog. There is no doubt that the aseptic method has got distinct advantages over the antiseptic method as applied to wounds because any substance which injures or destroys microbes will likewise injure the living cells of that part of the body to which it is applied. For this reason the aseptic method can only be employed to a very limited extent against microbes that have already entered the interior of the body, although it may sometimes be used, as for example in the treatment of dysentery, where repeated doses of saline purgative are now given so as to wash out from the intestinal canal the microbes which give rise to the disease, and even in ordinary diarrhea, where a purgative is employed to get rid of both the microbes and the poisons they have formed. More commonly, however, we have to depend on antiseptic methods either entirely or as an adjunct to asepsis, and a study of the action of various chemical substances on microbes has led to the introduction of a whole series of antiseptics and indeed to their actual synthetic formation, the problem to be solved being how to produce a body which will destroy the microbes most efficiently and at the same time will have the least injurious action upon the body of the animal invaded. Nor is it only inside the body that the action of antiseptics is desired. The search for preservatives for milk, meat, fish, vegetables, and fruit which shall be at the same time efficient and innocuous is one constantly going on at present. Asepsis is one of nature's methods of defense. When irritating substances get into the eye a flow of tears occurs to wash them away, from the nose and respiratory passages they are ejected by sneezing or by cough, and from the stomach or intestines they are removed by the vomiting and purging to which they themselves give rise. Even in the addition of preservatives in milk we seem to be following the example of nature because Andeer has found resorcin in which is an antiseptic in the fresh milk of cows. As Metchnikoff has shown, another method adopted by nature for removing and destroying infective microbes is to bring down upon them a host of white blood corpuscles, or leucocytes, which swallow up and destroy them. The more leucocytes that the organism can bring to bear upon the intruders the better chance it has of overcoming them. One problem, therefore, in therapeutics is to increase leucocytosis. At present we have comparatively few drugs that possess this power, cinnamate of sodium being perhaps the most active, but one of the problems to be solved is to find other substances which will do this to a greater extent than at present. The microbes on their part are ready to attack the leucocytes and fixed cells by means of toxic secretions or toxins and another of the defensive mechanisms which the organism adopts is to form *antitoxins*, as the antitodes to these toxins are generally termed. Some of these defensive bodies or alexins actually destroy the invading microbes themselves, while others simply neutralize the poisons or toxins they have formed. The nature of such defensive substances has been examined by Ehrlich to whom we owe much of our knowledge concerning them. It is very complicated and we do not yet know the precise mode of production of these antitoxins, but it is a curious fact that in many plants we find two poisons which are antagonistic in their action and which are to a certain extent antidotal to one another. Thus in jaborandi we have two alkaloids one of which, pilocarpine, stimulates secretion enormously, whilst the other, jaborine, paralyzes secretion, so that an extract of the jaborandi plant containing them in proper proportion might possibly appear inactive although it contained both alkaloids in considerable amount. The same is the case with poisonous mushrooms which contain a poisonous alkaloid, muscarin, which produces severe irritation of the intestine and an atropine-like substance which antagonizes it. Opium likewise contains alkaloids having very different actions, some being almost purely narcotic and others purely convulsant. The animal body seems to have a wonderful power of accommodating itself to the action of many poisons and this is very marked indeed in the case of opium. Many persons who begin with a small dose increase this gradually to an enormous extent so that they are able to take with impunity many times the ordinary lethal dose. The organism has a certain power of storing up antidotal substances within itself and Dr. Cash and I were able, by feeding animals with potash, to render them less susceptible to the poisonous action of barium, but except in the case of arsenic the organism seems to have but little power of becoming accustomed to inorganic poisons. It is different, however, in the case of organic poisons as shown by the resistance to the action of alcohol acquired by habitual topers and to morphine by habitual opium-eaters. A similar resistance may be acquired to snake-venom and to the toxins produced by microbes; and here it does not seem to be merely that the cells of the organism become accustomed to the poison, but that the organism forms an antidote, not only in sufficient quantity to neutralize the poison which is introduced, but actually in such superabundance that serum separated from the blood of an animal which has become immune to the action of snake-venom or of toxins will neutralize the effect of the venom or toxins in another animal. So great is this power that Sir T. R Fraser has found by inoculating an animal with gradually increasing doses that it may at length completely resist the action of fifty times the ordinary lethal dose of snake-venom, and in an experiment of M. Calmette I have seen an animal which had received the serum from such an immunized animal remain healthy and well, although another one which was inoculated at the same time and with the same dose of snake-venom was dying from the effect of the poison.

When horses are inoculated with successively increasing doses of the toxin of diphtheria, their blood acquires a high antitoxic power, and the use of the serum of such blood injected into patients suffering from diphtheria has robbed this disease to a great extent of its awful power. Hydrophobia is another disease which has been to a great extent deprived of its terrors by Pasteur's method of treatment. This differs in its plan from that used in diphtheria. In diphtheria the bacilli probably form a ferment which produces a deadly poison by exercising its digestive powers on the material it finds in the body. This poison is neutralized by the antidotal serum which is formed in a horse and is injected into the patient. In hydrophobia we have not been able to isolate the virus, but from its mode of action we suppose it to be a minute organism. This virus takes a long time to act in man, sometimes three weeks but usually six weeks, but when cultivated successively in rabbits it becomes very virulent indeed and acts much more quickly. It apparently finds its chief nidus in the spinal cord. When the cord is exposed to air the virus gradually becomes weakened and by injecting with an extract of very weak cord on the first day and with a stronger extract on each succeeding day the human body becomes accustomed to the virus and forms its own antitoxins. Thus by the time that the poison inoculated by the original bite of the rabid animal has time to develop its action the person has become immune.

One of the most important problems of therapeutics, therefore, is to render the human body immune against pathogenic microbes, against the ferments they form, and the toxins they produce. The two examples I have already given show how the toxins and possibly the ferments may be rendered innocuous by injecting antidotal sera and thus producing what is called "*passive immunity*," or by exciting the body to form antidotal substances itself and thus produce what is called "*active immunity.*" Both these methods have been used, and are being used, in regard to other diseases, especially in those produced by micrococci of various sorts which give rise to suppuration and inflammations. One great difficulty in the way, however, is that the antidotal serum produced by one coccus is not always efficient against the disease produced by another, and so much is this the case that it would almost seem as if an antidotal serum would require to be made for each particular patient. Nor are the sera altogether innocuous themselves because their injection may be followed not only by annoying rashes on the skin but by general swelling of the body like that from advanced kidney disease, or by painful swelling of the joints almost like rheumatic fever. Another of the problems of therapeutics therefore is to obtain anticoccic sera which will not produce any unpleasant or dangerous symptoms.

Yet another is to confer on the tissues of the body the power of resisting or destroying microbes, their ferments, and their toxins, and thus protecting themselves or in other words acquiring immunity against the diseases which the microbes would produce. In considering this question it may help us if we remember that the products of our own digestion are poisonous and if the albumoses and peptones formed by the digestion of a beef-steak in the stomach were injected directly into a man's veins they would kill him, whereas, when changed by the cells of the intestine and liver in the process of absorption, they nourish and strengthen him.

The complexity of toxins and antitoxins is easily understood when we consider that they are probably all formed by the splitting-up of albuminous molecules and thus vary enormously just as the splinters of a broken glass vary in size, shape, and in power to puncture or cut.

In my address at Moscow, in 1897, I ventured to formulate the idea that immunity, natural or acquired, is nothing more than an extension to the cells of the tissues generally of a power which is constantly exercised during digestion by those of the intestine and liver. When microbes were just beginning to be recognized as the cause of infective disease, too much importance was attached to the mechanical effects which they might produce in the blood-vessels and tissues. As their mode of action became better known, this view was to a great extent given up, but though the small vegetable microbes, bacilli and cocci, have little injurious mechanical action, this is not the case with some minute organisms belonging to the animal kingdom, and such organisms of late years have become more and more recognized as causes of diseases. In elephantiasis the lymph channels become blocked by the ova of a small worm which inhabits the blood and thus the enormous swelling characteristic of the disease is produced. Within the last few years that dreadful scourge of tropical countries, malaria, has been discovered to be due to an animal parasite, and Manson and Ross have shown that the source of infection is the mosquito. By destroying mosquitoes or preventing their multiplication the disease can be to a great extent prevented, but we are still dependent upon bark, quinine, and arsenic as remedies to destroy the parasite and cure the disease. These are not invariably successful and we are still in want of medicines which shall infallibly destroy the parasite. The same is the case with other maladies where the infective microbe is of animal origin, as in sleeping-sickness, which is now attributed to a minute worm in the blood, or of vegetable origin as in ulcerative endocarditis, or of uncertain origin as in yellow fever.

But all these diseases excite much less attention than that which is perhaps more dreaded than any other in temperate climates, namely, cancer. We do not as yet know the pathology of this disease. It has been shown that in it the cells of the affected part multiply and grow in a different manner from that of ordinary tissues. They assume a reproductive type and grow independently of the tissues of the body in which they are situated.

We know that portions of carcinomatous growths may be carried by the blood-stream from one part of the body to another where they may act as new foci, but that they can only be transplanted with difficulty if at all from one animal to another. Thus it is evident that though their reproductive power is great their vitality is feeble. Therefore what one may hope for is, that though all the drugs hitherto tried have been powerless to prevent the life and growth of such tumors, yet something may yet be found which will attack and destroy them and nevertheless leave uninjured the healthy tissues by which they are surrounded. Lupus and rodent ulcer situated on the surface of the body have been successfully treated by the X-rays and ultra violet rays. These have little effect on deep-seated cancer. My friend, Sir William Ramsay, thinks, however, that the emanations from radium, which are to a certain extent soluble in water, might be administered with a view of destroying internal cancer, more especially as he has already found that they seem to have no injurious action when given to healthy animals. In the case of cancer it is certain that groups of cells take on a life of their own, and live independently of the wants of the organism as a whole. In some other diseases we find that entire organs become too active and thus injure the health of the whole body. One of the best examples of this is the thyroid gland which, when hypertrophied, produces, through the secretion which it pours into the blood, a curious set of nervous symptoms, dilatation of the vessels, palpitation of the heart, tremor, restlessness, excitement, and rise of temperature. In the disease known as Graves's Disease these symptoms exist and may possibly be aggravated by the condition of the nervous system which causes the characteristic protrusion of the eyeballs and may even be the cause of the swelling of the thyroid itself. But that most of the symptoms are really due to the action of the thyroid secretion is shown by the fact that they may all be observed after excessive administration of dried thyroid gland.

Here we have a toxin formed within the body by the over-action of one of its parts and at present we have no satisfactory antitoxin by which we can remove the symptoms, although supra-renal gland has an action somewhat antagonistic to that of the thyroid, and this gland or its extract when administered internally in cases of exophthalmic goitre sometimes appears to be beneficial. The case is very different, however, when, instead of being excessive, the action of the thyroid is deficient. When this occurs in adults the circulation becomes poor, the skin cold, the movements of the body and the action of the mind slow, the aspect becomes dull and heavy, and the features puffy and swollen. When thyroid gland or its extract is given, all these symptoms disappear and the patient becomes healthy for the time and usually remains so as long as the administration is continued. When deficiency of the thyroid occurs in childhood, the effect of treatment is still more manifest, for the child thus affected becomes stunted both in body and mind, is dwarfish, feeble, and idiotic. Under the administration of thyroid it grows rapidly and becomes strong and intelligent and indeed develops into a perfectly normal person. The cure effected by thyroid in such cretins is one of the most marvelous achievements of therapeutics and many attempts have been made with portions of other organs or extracts of them to supply material which is supposed to be absent in various diseases.

The first instance of this method of treatment, or *opotherapy*, as it is called, was, I believe, my employment of raw meat thirty years ago to supply the body with a ferment to use up sugar in diabetes.[1] The method was reintroduced by Brown-Sequard with more success, but it was not until the use of thyroid gland and its extract that the potentialities of the method became acknowledged. It is more than eighteen hundred years since the question was asked "Who can add a cubit to his stature?" and all this time we have remained ignorant of any plan by which we could add a single inch to a child's stature. Yet it now seems possible that by the use of thyroid gland and pituitary body, children, who would be otherwise stunted, may grow not only to the normal size but even above it.

So long, however, as we do not know the chemical nature of the substances which exercise such an extraordinary effect upon tissue change we shall not be able to deal with them so satisfactorily as we can now, in a way that was formerly impossible, regulate the temperature in fever. The clinical thermometer not only shows us the extent to which fever is present, but it enables us to stop the application of our remedies in time so as not to reduce the temperature to too great an extent. Cold water, ice, and diaphoretics were formerly the only antipyretic remedies, next salicin and quinine were introduced, then salicylic acid was made synthetically, and being cheap was used extensively, and within the last thirty years an increased knowledge of chemical methods and of the relationship between chemical constitution and physiological action has enabled numerous synthetic products to be formed, some of which may be more useful in certain cases than the original salicylate of soda.

A great many of these substances primarily intended to reduce the temperature have turned out to have a still more important action, namely, the relief of pain. There is no doubt that pain is useful as a warning against conditions which tend to destroy the organism and leads us to shun or remove these conditions to the great advantage of our health, but it is not always possible to do

[1] *British Medical Journal*, 1873.

this and pain *per se* is one of the greatest evils that poor humanity has to bear. The introduction of antiseptics has completely revolutionized the art of surgery because it allows operations to be done with almost certain success which would in former days have almost inevitably proved fatal from unconscious contamination of the wound by disease-germs. But the greatest triumphs of surgery have only been rendered possible by the discovery of anesthetics. Previous to the work of Long, Jackson, Wells, Warren, and Simpson rapidity of operation was everything, and careful but long-continued manipulation was impossible because the long-continued pain of the operation would inevitably have killed the patient. Even the minor pains of neuralgia, neuritis, and headache, though not dangerous to life, are most distressing to the sufferer. Formerly there was almost no drug to relieve these excepting opium, while now we have phenacetin, antipyrin, phenalgin, and a host of others, and chemists are daily at work preparing new and perhaps even better pain-killers.

Hardly, if at all, less distressing than pain is sleeplessness, and here again our powers of helping the patient have been enormously increased of late years. When I was a student almost the only hypnotics used were opium, henbane, and Indian hemp. The latter two were very unsatisfactory and practically one pinned one's faith on opium which had to be combined with tartar emetic in cases of fever. Then came the introduction by Liebreich of chloral, which was not only a great boon in itself but marked an epoch as one of the first instances of rational therapeutics, the application of a certain drug in disease because of its pharmacological action. Now we have any number of hypnotics, some of which are useful because they act on the nervous system itself and produce sleep without depressing the heart and can thus be given where the circulation is already weak, while others, like chloral, not only act on the cerebrum but lessen the force of the circulation, and by thus diminishing the flow of blood through the brain assist it to rest and aid the onset of sleep. Formerly when the circulation was too active the chief depressants were mercurial and other powerful purgative medicines, bleeding, tartar emetic, vegetarian diet, or partial starvation. Although these means may still be employed with advantage in proper cases, yet we have in addition a new set of remedies, viz., vaso-dilators, including nitrites, nitrates, and possibly a good many substances which dilate the vessels and lower the tension in the arteries, a tension which may be dangerous on the one side to an enfeebled heart and on the other to an atheromatous artery in the brain.

When the heart is failing we have a series of cardiac tonics and stimulants. Foremost amongst these, perhaps, may be put strychnine, the action of which on the heart was practically unknown when I was a student, and perhaps now it is hardly sufficiently recognized. At the time of which I speak, digitalis was looked upon as a cardiac depressant, and almost the only cardiac stimulant that was known was alcohol. Now digitalis, strophanthus, and a number of others are regularly used as cardiac tonics, and their power of contracting the vessels is also sometimes useful in removing dropsy. When this action is likely to be harmful to a weak heart, it may be lessened by the simultaneous administration of vascular dilators. We still, however, want drugs which will act only on the heart, or only on the vessels. We require medicines which will diminish the cardiac action and dilate the vessels for use in high tension, such as so often occurs in gout, and we need drugs which will make the heart beat more forcibly while they cause the vessels to contract and raise the tension in cases of debility.

But prevention is better than cure, and if by modifying tissue-change we can obviate the high tension and hypertrophy of the heart which so frequently lead to apoplexy, or the atheromatous condition of the vessels which leads to senile degeneration of the brain or premature old age, we shall lessen the necessity for either cardiac tonics or vascular dilators. Some authorities claim that they can do this by vegetarian diet, limited in quantity as well as in quality, while others would treat it by a diet almost entirely of meat with liberal potations of hot water. The subject of diet is one regarding which the most contradictory opinions prevail and there is a sad want of precise knowledge upon which to base dietetic rules. We may hope, however, that the investigation at present being conducted by Professor Atwater under the United States Government, combined with that which is being carried on under the auspices of the Carnegie Trustees, will furnish the information we need.

Time will not allow me to do more than mention aerotherapeutics, balneotherapeutics, and hydrotherapeutics; the rest-cure which is associated with the name of one of America's most brilliant and versatile sons, Weir Mitchell; massage and movements which Ling and his pupils, both in Sweden and elsewhere, have done so much to elaborate and which when rightly used may be so beneficial and wrongly used so harmful. For all these branches of therapeutics we require a more exact knowledge of their action and the rules for employing them, so that even those who have made no special study of them may employ them rightly in all diseases in which they may be of service.

Another method of cure consists in eliminating waste products from the body by rendering them more soluble and while limiting the water drunk would give lithia, piperazine, piperidine, and other substances which increase the solubility of uric acid. Before therapeutics can make much advance in this direction we must know more about the pathology of gout and tissue-metabolism generally, and we may then hope that not only will people be more free from the manifold symptoms that gout produces, but will live longer and the time of their activity, bodily and mental, will continue nearly as long as life itself. The power of increasing elimination of nitrogenous waste which urea possesses in a marked degree is shared by other substances belonging to the so-called purin group and day by day fresh bodies belonging to this chemical group are being made synthetically. Some of the new ones seem to have a greater power of eliminating waste than any we have hitherto had. The observations of Richardson, that alcohols vary in their action according to their chemical composition, and of Crum, Brown, and Fraser, that alteration in chemical constitution brings about a change in physiological action, are now beginning to bear rich fruit, and the synthetic preparation of remedies having different pharmacological properties along with our increasing knowledge of pathology gives us much hope for the future of therapeutics. More than two hundred years ago, Locke said: "Did we know the [mechanical] affections of rhubarb, hemlock, opium, and a man as a watchmaker does those of a watch, whereby it performs its operations, and of a file which by rubbing on them will alter the figure of any of the wheels, we should be able to tell beforehand that rhubarb will purge, hemlock kill, and opium make a man sleep." One of the great problems of therapeutics is not only to know (*a*) what drugs to use in order to obtain certain effects, but to know (*b*) how to make such drugs if we have not got them at hand. The struggle for existence does not occur only between man and beast, man and man, or nation and nation, nor even between individual beasts or plants. It takes place also between cell and cell, not only between those cells which we term microbes and the cells which form the human body, but even between those which form the different parts of the body itself.

The great object of this Congress is to unify knowledge, to render evident the similarity of the laws which govern phenomena of the most diverse character, and it is therefore interesting to find that the grand problem of therapeutics is for the cell what those of religion and sociology are for the man, viz., to learn how to regulate the environment of each cell or man in such a manner that the individual shall not work for his or its own good alone, but for that of others as well, and how to restrain or destroy those which are noxious. When we are able to regulate cell-life by food, air, water, exercise, inoculations, or medicines, we shall be able to relieve or remove weakness, pain, or distress, not only from the bodies but also from the minds of our patients, to maintain health, increase strength, and prolong life to an extent of which at present we can hardly dream.

SHORT PAPER

Dr. Reid Hunt, Pharmacologist of the United States Public Health and Marine Hospital Service, presented a paper to this Section on "The Relation of Acute and Chronic Alcoholism to some other Forms of Poisoning."

SECTION E—INTERNAL MEDICINE

SECTION E — INTERNAL MEDICINE

(*Hall* 13, *September* 23, 3 *p. m.*)

CHAIRMAN: PROFESSOR FREDERICK C. SHATTUCK, Harvard University.
SPEAKERS: PROFESSOR T. CLIFFORD ALLBUTT, F. R. S., University of Cambridge.
PROFESSOR WILLIAM S. THAYER, Johns Hopkins University.
SECRETARY: DR. R. C. CABOT, Boston, Mass.

THE HISTORICAL RELATIONS OF MEDICINE AND SURGERY

BY THOMAS CLIFFORD ALLBUTT

[**Thomas Clifford Allbutt,** Regius Professor of Physic, Cambridge, England. **b.** Dewsbury, England, 1836. M.A., M.D., Cambridge; (Hon.) D.Sc. Oxford; (Hon.) M.D. Dublin; (Hon.) D.Sc. Victoria; (Hon.) LL.D. Glasgow; F. R. C. P. London; (Hon.) F. R. C. P. Ireland. Physician, Leeds, England, General Infirmary, 1865–85; Consulting Physician, also, to the Belgrave Hospital for Children, London; Commissioner in Lunacy, 1889–93; Physician to the Addenbrooke's Hospital, Cambridge; Fellow of the Royal Society; Fellow of the Linnean Society of London; Fellow of the Society of Antiquaries, London; Honorary Member of the New York Academy of Medicines. **Author** of many medical works; *Science and Medieval Thought; Historical Relations of Medicine and Surgery.*]

IT was, I think, in the year 1864, when I was a novice on the honorary staff of the Leeds General Infirmary, that the unsurgical division of us was summoned in great solemnity to discuss a method of administration of drugs by means of a needle. This method having obtained some vogue, it behoved those who practiced "pure" medicine to decide whether this operation were consistent wiith the traditions of purity. For my part, I answered that the method had come up early, if not originally in St. George's Hospital, and in the hands of a house physician, Dr. C. Hunter; that I had accustomed myself already to the practice, and proposed to continue it; moreover, that I had recently come from the classes of Professor Trousseau, who, when his cases demanded such treatment, did not hesitate himself to perform paracentesis of the pleura, or even incision of this sac or of the pericardium. As for lack, not of will, but of skill and nerve, I did not intend myself to perform even minor operations, my heresy, as one traitorous in thought only, was indulgently ignored; and we were set free to manipulate the drug needle, if we felt disposed to this humble service. About this time certain Fellows of the London College of Physicians, concerned with the diseases of women, had been making little operations about the uterus, and meeting with but slight rebuke, they rode on the tide of science and circumstance, encroaching farther and farther, until they were discovered in the act of laparotomy; and rather in defiance than by conversion of the prevailing sentiment within those walls, they went on doing it.

Meanwhile the surgeons, emboldened by great events in their mystery, wrought much evil to the "pure" physicians; accusing them with asperity of dawdling with cases of ileus and the like until the opportunity of efficient treatment had passed away: nay, audacious murmurs were heard that such "abdominal cases" should be admitted into surgical wards from the first. Then, by dexterous cures, growing bolder and bolder, the surgeons went so far as to make a like demand for cases of tuberculous peritonitis, of empyema, and even of cerebral tumor. As thus the surgeons laid hands on organ after organ which hitherto had been sacred to "pure" medicine, and as indeed the achievements of surgery became more and more glorious, not only the man in the street but the man of the Hospital Committee also began to tattle about the progress of surgery and the diminution of medicine, until it was only by the natural sweetness of our tempers that the surgeon and the inner mediciner kept friends. At a dinner given on June 30 last to Mr. Chamberlain, in recognition of his great services to tropical medicine, this vigorous statesman said, "I have often heard that while surgery has made gigantic progress during the last generation, medical science has not advanced in equal proportion;" then, while modestly disclaiming the knowledge to "distinguish between the respective claims of these two great professions," he generously testified that "medical research assisted by surgical science has thrown a flood of light on the origin of disease, and that this at any rate is the first step to the cure of disease." Now Mr. Chamberlain is the first of English statesmen to ally himself actively with our profession; the first with imagination enough to apprehend the great part which medical science is playing in the world already, and to realize that only by medicine can vast surfaces of the earth be made habitable by white men, and those "great assets of civilization," the officers of our colonies, be saved alive. It seems to me, then, that the present is a critical moment in the relations of medicine and surgery, especially in England, where the two branches of the art have been separated so radically as to appear to be "two professions;" a moment when it is our duty to contemplate the unity of medicine, to forecast its development as a connected whole, and to conceive a rational ideal of its means and ends. But this large and prophetic vision of medicine we cannot attain without a thoughtful study of its past.

If, as from a height, we contemplate the story of the world, not its pageants, for in their splendor our eyes are dim, but the gathering, propagation, and ordination of its forces, whence they sprang, and how they blend this way and that to build the ideas and institutions of men, we may wonder at their creative activity, or weep over the errors and the failures, the spoliation and the decay, which have marred or thwarted them; and if we contemplate not the whole but some part of men's sowing and men's harvest, such a part as medicine, the keener is our sorrow and disappointment, or our joy and our hope, as we admire the great ends we have gained or dwell upon the loss and suffering which have darkened the way. "In the development of medicine," said Helmholtz, "there lies a great lesson on the true principles of scientific progress."

Pray do not fear, however, that to fulfill the meaning of the title of this address, I shall describe to you the history of medicine and the history of surgery, and on this double line compare and combine my researches; in the time allotted to me no such survey is possible. In the seventeenth century the handicrafts of anatomy, chemistry, and physiology so penetrated medicine that the separate influence of surgery is less easily discernible. My purpose, therefore, is to pass in review certain eminent features of the history of these departments of knowledge up to the end of the sixteenth century, and to compare them with a view to edification; your fear will be rather that I may tell my story with the unrighteousness of a man with a moral.

In his address on "Morgagni," at Rome, in 1894, Virchow said that medicine is remarkable in its unbroken development for twenty-five centuries; as we may say, without irreverence, from Hippocrates to Virchow himself. The great pathologist's opinion, however, seems to need severe qualification; if it be so, the stream has more than once flowed long underground. The discontinuity of medicine from Egypt to Crotona and Ionia is scarcely greater than from Galen to Avicenna; during which period, in spite of a few eminent teachers in the Byzantine Empire, it sank, in the West at any rate, into a sterile and superstitious routine.

Classical medicine, the medicine of the fifth century, B. C., is represented for us by the great monument of the Scriptures collected under the name of the foremost teacher of the age, Hippocrates; in genius perhaps the greatest physician of all past time. The treatises of the Canon may be divided into medicine, surgery, and obstetrics. The medical treatises, when read in an historical spirit, command our reverent admiration. Written at a time when an inductive physiology was out of reach, we are impressed nevertheless by their broad, rational, and almost scientific spirit. Medicine, even when not dominated by contemporary philosophy, has always taken its color from it; and the working physiology of Hippocrates was that humoral doctrine, originally derived from Egypt and the East, which, as enlarged by Galen, ruled over medicine till recent times. Hippocrates, while distinguishing between the methods of outward and inward maladies (φανερὰ καὶ ἄδηλα νοσήματα), taught that even for the inner, by careful sight and touch, laborious inspection of excretions, and so forth, many facts are accessible to methodical investigations; yet, as in inner diseases the field for inference is more spacious, the data even of direct observation fell the more readily into the scheme of the four humors, and by this doctrine were so colored that, although observed with a rare clinical insight, they were set in the frame of a fictitious pathology.

How was it then that the speculative side of the medicine of Hippocrates embarrassed him so little? Because the clinical method of the school was soundly based upon the outward maladies, where direct induction was practicable. No sooner indeed does an inward affection — an empyema for example — work outwards than the mastery of Hippocrates becomes manifest. What we separate as surgery, surgery which, from Guy to Paré, by clerks, faculties, and humanists was despised as vile, and from Paré to Hunter as illiberal, was in the age of Hippocrates, as in all critical epochs of medicine since that age, its savior.

If then our admiration of the inner medicine of Hippocrates, great as it is, is a relative admiration, an admiration of the historical sense, of his outer medicine our admiration is instant and unqualified. Little as the fifth century knew of inward anatomy, as compared with Alexandria about two centuries later, yet the marvelous eye and touch of the Greek physician had made an anatomy of palpable parts — a clinical anatomy — sufficient to establish a medicine of these parts of the body of which our own generation would not be ashamed.

In respect of fractures and luxations of the forearm, M. Pétrequin pronounces Hippocrates more complete than Boyer; in respect of congenital luxations richer than Dupuytren. Malgaigne again admires his comparison of the effects of unreduced luxations on the bones, muscles, and functions of the limb in adults, in young children, and before birth, as a wonderful piece of clinics. In Littré's judgment, the work of Hippocrates on the joints is a work for all time. On wounds Littré pronounces that the Hippocratic books must be pondered with deep attention; for they are founded on a wide experience, minute and profound observation, and an enlightened and infinitely cautious judgment. Permit me to call your attention, however, to certain of his counsels: That a wound be let bleed, in order to prevent inflammatory consequences; that if in fresh wounds healing by first intention may take place, suppuration or coction is the usual, and in less recent and in contused wounds the normal course; also that wounds should be treated with linseed and other poultices: counsels which, as we shall see presently, were to be as hotly contested in the thirteenth and fourteenth centuries as in the nineteenth. From amputation of the larger limbs he flinched, as did most if not all responsible surgeons down to Paré; for inner anatomy was ill-known, and ligature, even in wounds, made slow way, indeed, before Celsus, seems to have been unknown. Caries was not definitely distinguished from necrosis, but a case of disease of the palate with fallen nose irresistibly suggests syphilis. Of eye diseases we find much of interest; of obstetrical practice I must be content to say that it had reached a high standard; and to state once for all that when surgery flourishes obstetrics flourish.

It is by comparison of one part of the Hippocratic Canon with another that we learn how a strong grasp of inner medicine was attained by way of intense devotion to its inductive or surgical side. And this not by a mere empiricism; for it may have been from Hippocrates that Aristotle learned how by empiricism (ἐμπειρία) we perceive a certain remedy to be good for this person or for that — for Socrates, let us say, or for Callias — when he has a certain fever; but that by reason we discern the characteristic common to all these particular persons, wherein they react alike. In his *Book of Precepts* Hippocrates tells us that τριβὴ μετὰ λόγου is the basis of all medical knowledge. Now τριβή is primarily a grinding or rubbing; so the student must rub and grind at nature, using his reason at the same time; but his reason must be a perceptive and interpretative not a productive faculty, for he who lends himself to plausible ratiocination (λογισμῷ πιθανῷ προσέχων) will find himself ere long in a blind alley; and those who have pursued this course have done no enduring service to medicine. How soundly, for the time, this lesson was learned we see in the theoretical appreciation of these several faculties in the first chapter of Aristotle's *Metaphysics* and in the Sixth Book of the *Ethics*, where the senses, it is urged, cannot really be separated from the mind, for the senses and the mind contribute each an element to every knowledge. I am disposed to suggest that this method of observation, experience, and judgment was established first in medicine, because medicine is both practical and imperative; and, as Aristotle points out, concerned with the individual patient: to our art, then, may belong the honor of the application of positive methods to other sciences.

The chief lesson of the Hippocratic period for us is that, in practice as in honor, medicine and surgery were then one; the Greek physician had no more scruple in using his hands in the service of his brains than had Pheidias or Archimedes; and it was by this coöperation in the fifth century that the advance was achieved which in our eyes is marvelous. As we pursue the history of medicine in later times we shall see the error, the blindness, and the vanity of physicians who neglected and despised a noble handicraft. The clear eyes of the ancient Greeks perceived that an art is not liberal or illiberal by its manipulations, but by its ends. As, because of its ends, the cleansing and solace of the lepers by St. Francis and Father Damien was a service of angels, so Hippocrates saw no baseness even in manipulations, which obtained for his followers the name of *coprophagi;* where there is no overcoming there is no victory.

Between Hippocrates and Galen, an interval of some five centuries, flourished the great anatomical and medical schools of Alexandria. Our only important source, however, for the medicine of the Alexandrian period is Celsus, who lived in the reign of Augustus. In Celsus we find that the surgical and obstetrical sides of it had made farther and substantial progress. Celsus, perhaps not himself a practitioner, is sometimes vague in detail; still, beyond the Hippocratic surgery, we read of treatment in piles, fistula, rodent ulcer, eczema, fractures, and luxations; the nasal passages were cauterized for ozena; dropsies were systematically tapped; hernias were submitted to radical cure; plastic operations were undertaken, and the larger limbs were deliberately amputated, though only in extreme need, and often with fatal results by secondary hemorrhage and otherwise.

How active surgery was from Celsus to Galen, and how honorable and progressive a part of medicine, we know from the scanty records of Archigenes of Apamea, who also practiced in Rome, in the reign of Trajan. Galen calls him an acute but too subtle a physician; such of his subtleties, however, as are known to us — his distinction between primary and consequential symptoms for instance — are to his credit. He applied the ligature in amputations, and Antyllus applied the method to the cure of aneurism, which indeed Rufus seems to have done before him. Galen tells us where he got his "Celtic linen thread" for the purpose, namely, "at a shop in the Via Sacra between the Temple of Rome and the Forum." We learn also, from Oribasius, that Antyllus practiced extensive resections of bone in the limbs, and even in the upper and lower jaw.

Galen came to Rome under Marcus Aurelius. In the biological sciences this great physician stands to Harvey, as in physics Archimedes stood to Galileo and to that other great physician, William Gilbert; Galen was the first, as for many centuries he was the last, to apply the experimental method to physiology. He embraced the ancillary sciences, he opened out new routes, and he improved the old. Unhappily, his soaring genius took delight also in speculation; and it was not the breadth of his science, nor the depth of his methodical experiment, but the height of his visionary conceits which imposed upon the Middle Ages. Galen did not himself forget the precept of Hippocrates: To look, to touch, to hear (καὶ ἰδεῖν, καὶ θιγεῖν, καὶ ἀκοῦσαι); but he did not wholly subdue himself to the πεῖρα τριβικὴ — this toilsome conversation with troublesome facts. Galen did not make any great mark on surgery; his tracts on the eye are lost; but, so far as we know, his surgery was adopted in the main from the Alexandrians and from Soranus. However, Galen successfully resected the sternum for caries, exposing the heart; and he excised a splintered shoulder-blade: moreover, with all his bent to speculative reason, we have no hint that he fell into the medieval abyss of regarding surgery as unfit for a scholar and gentleman.

After Soranus and Galen medicine came to the evening of its second day, to the long night before the rise of the Arabian, Italian, and French surgeons of the twelfth, thirteenth, and fourteenth centuries.

In spite of the docile industry of Greek physicians of the Byzantine period, medicine gradually sank not into sterility only, but into degradation. The wholesome discipline of practical surgery had fallen off. Eastern folk, who bear heaven-sent sores with fatal stoicism, shrunk from the profane hand of man; and the tradition of Galen made for a plague of drugs which were least mischievous when merely superfluous. Rhazes, Albucasis, Avicenna the Arabian Galen, had entered by the door of the East into a great scientific inheritance, and, if they did little to develop surgery, it still was with them a grave and an honorable calling; with them medicine had not yet lost her right arm. The small benefits of the Church to medicine issued in a far greater treachery. The Greek of Ireland, and of England in the time of Bede, was banished by Augustine and the Benedictine missionaries; and the medicine of Monte Cassino, itself a farrago of receipts, in the monkish hostels of the West fell lower and lower. We have reason, however, to believe that even in the cloister some fair surgery was making way, when it was finally abandoned to the "secular arm" by the Council of Tours, in A. D. 1163; and books on surgery and midwifery began to disappear from the clerical libraries. The University of Paris excluded all those who worked with their hands; so that its students of medicine had to abjure manual occupation, and to content themselves with syllogisms and inspections of urine, often, indeed, without any inspection of the patient himself. From the University the Faculty of Medicine took its tone, and the Surgical Corporation of St. Come aped the Faculty. But by the expulsion of surgery from the liberal arts, and the societies of learned men, medicine herself was eviscerated; thus was made the pernicious bisection of medicine which has not yet spent its evil; the inductive foundations of the art were removed, and the clergy and the faculties, in France and England at any rate, devoted all their zeal to shoring-up the superstructure. Surgery saw its revenge, its bitter revenge; but in the ruin of its temple. In the thirteenth and fourteenth centuries surgery, hated and avoided by medical faculties, scorned in clerical and feudal circles, began in the hands of lowly and unlettered men to grow from a vigorous root; while inward medicine, withdrawing itself more and more from the laboratory of nature, hardened into the shell which till the seventeenth century was but a counterfeit. The surgeons of the thirteenth, fourteenth, and fifteenth centuries, reared in humble apprenticeships, not illiterate only, but forbidden the very means of learning, lay under heavy disadvantages; yet, such is the virtue of practical experience, inductive method, and technical resource, that by them the reform of medicine was made. Towards the end of the fifteenth century, indeed, this progress had slackened, soon to be reinforced, however, by new and urgent problems, not of the schools, but of direct rough and tumble with nature. Of these new problems, of which Paré became the chief interpreter, new epidemics and the wounds of firearms were the chief.

In medicine from the twelfth to the eighteenth centuries Italy led the world; in the schools of Salerno, Naples, Bologna, Padua, was contained a strong lay and imperial tradition which gave pause to clerical ascendency. Bologna, until the predominance of her law school, was indeed a large and plenteous mother to medicine in its full orb; but already in Salerno far-seeing men had begun to dread the divorce of surgery from inner medicine. The important Salernitan treatise of the end of the twelfth century, *The Glosses of the Four Masters on the Surgery of Roger and Roland*, edited by Daremberg and de Renzi, begins with a lament on the decadence of surgery, which they attribute to two causes; namely, the division of surgery from medicine, and the neglect of anatomy. By the wisdom of Bologna and Naples, where chairs of surgery were founded, this ill-starred divorce was postponed; in his University of Naples indeed Frederick the Second made it a condition that surgery should be an essential part of medicine, should occupy as long a course of study, and should be established on anatomy "without which no operator can be successful."

Roger's *Practica Chirurgiae* was written in 1180, and though of course it rests upon the traditional surgery of his day, there are not a few points of interest in the book, such as certain descriptions suggestive of syphilis. For hemorrhage Roger used styptics, the suture, or the ligature; the ligature he learned no doubt from Paul of Egina; but Roger, like most or all qualified physicians of the period, was a "wound-surgeon" only, that is, he did not undertake the graver operations. He was in favor, as a rule, of immediate extraction of weapons from their wounds; but in these wounds, even after extraction, he encouraged suppuration by stimulating applications within and around them, and dressed them with ointments on lint. To these points, especially to the promotion of pus, and the unctuous dressings, permit me again to draw your attention; for we enter now upon a surgical controversy which, pale reflection as it may be of the great surgical dayspring of the nineteenth century, is, historically speaking, of singular interest.

Hugh, of Lucca, says Malgaigne, is the first of the surgeons of modern Europe whom we can cite with honor. This tribute is a little strained; we may say, however, that of these honorable ancestors Hugh seems to have been a chief. I say "seems to have been;" for Hugh is even a dimmer giant than Roger or Roland. We know that he was born of honorable family about the middle of the twelfth century; that he served as surgeon in the campaigns, and was present at the siege of Damietta; but of writing he left not a line. Such vision as we have of him we owe to his loyal disciple, probably his son, the Dominican Theodoric, Bishop of Cervia, and master of Henry of Mondeville. He completed his "surgery" in 1266, but his life was almost coterminous with the thirteenth century. What was Theodoric's message? He wrote thus: "For it is not necessary, as Roger and Roland have written, as many of their disciples teach, and as all modern surgeons profess, that pus should be generated in wounds. No error can be greater than this. Such a practice is indeed to hinder nature, to prolong the disease, and to prevent the conglutination and consolidation of the wound." In principle what more did Lister say than this? Henry of Mondeville made a hard fight for the new principle, but the champions of Galenism and suppuration won all along the line; and for five following centuries poultices and grease were still to be applied to fresh wounds, and tents, plastered with irritants to promote suppuration, were still to be thrust into the recesses of them, even when there was no foreign body to be discharged. If after all this, erysipelas set in — well, says Henry, lay it at the door of St. Eligius! Hugh and Theodoric for the fresh wound rejected oil as too slippery for union, and poultices as too moist; they washed the wound with wine, scrupulously removing every foreign particle; then they brought the edges together, forbidding wine or anything else to remain within. Dry and adhesive surfaces were their desire. Nature, they said, produces the means of union in a viscous exudation, or natural balm as it was afterwards called by Paracelsus, Paré, and Würtz. In older wounds they did their best to obtain union by cleansing, desiccation, and refreshing of the edges. Upon the outer surface they laid only lint steeped in wine. Powders they regarded as too desiccating, for powder shuts in decomposing matters; wine, after washing, purifying, and drying the raw surfaces, evaporates. The quick, shrewd, and rational observation, and the independent spirit of Theodoric, I would gladly illustrate farther did time permit; in passing, I may say that he was the first to notice salivation as the result of administration of mercury in "skin diseases."

Both for his own merits, and as the master of Lanfranc, William Salicet was eminent among the great Italian physicians of the latter half of the thirteenth century. Distinguished in surgery, both as practitioner and author, he was also one of the protestants of the period against the division of the craft from inner medicine; a division which he justly regarded as a withdrawal of medicine from intimacy with nature. Like Lanfranc and all the great surgeons of the Italian tradition, and unlike Franco and Paré, he had the advantage of the liberal university education of Italy; but, like Paré and Würtz, he had also large practical experience in camp, hospital, and prison. His *Surgery* contains many case-histories. He discovered that dropsy may be due to a "durities renum;" he substituted the knife for the abuse of the cautery by the followers of the Arabs; he pursued the investigation of the causes of the failure of healing by first intention; he described the danger of wounds of the neck; he forwarded the diagnosis of suppurative disease of the hip, and he referred chancre and gangrene to "coitus cum meretrice."

The *Chirurgia Magna* of Lanfranc of Milan and Paris, published in 1295-96, was a great work, written by a reverent but independent follower of Salicet. He distinguished between venous and arterial hemorrhage, and generally used styptics; white of egg, aloes, and rabbit's fur was a popular styptic in elder surgery, though in severe cases ligature was used. Learned man as he was, Lanfranc saw the more clearly the danger of separating surgery from medicine. "Good God!" he exclaims, "why this abandoning of operations by physicians to lay persons, disdaining surgery, as I perceive, because they do not know how to operate . . . an abuse which has reached such a point that the vulgar begin to think the same man cannot know medicine and surgery. . . . I say, however, that no man can be a good physician who has no knowledge of operative surgery; a knowledge of both branches is essential" (*Chirurgia Magna*).

Henry of Mondeville, of whom we hear first in 1301, as surgeon to Philip the Fair, was for the most part a loyal disciple of Lanfranc, and, aided as it would seem by Jean Pitard, also surgeon to the King, attempted for wounds to introduce the new methods of Hugh and Theodoric; for his pains he exposed himself to bad language, threats, and perils; and "had it not been for Truth and Charles of Valois," to far worse things. So he warns the young and poor surgeon not to plow the sand; but to prefer complaisance to truth, and ease to new ideas. I may summarize, briefly, the teaching of Henry on the cardinal features of the new method:

Wash the wound scrupulously from all foreign matter; use no probes, no tents — except under special circumstances; no oily nor irritant applications; avoid the formation of pus, which is not a stage of healing, but a complication; do not, as Galen teaches, allow the wound to bleed with the notion of preventing inflammation, for you will only weaken the patient's vitality (*virtus*), give him two diseases instead of one, and foster secondary hemorrhage; distinguish between oozing hemorrhage, hemorrhage by jets, and that which pumps out of an inward wound, using for the first, styptics, and for the last two the cautery, or, where practicable, digital compression for not less than a full hour; when your dressings have been carefully made, do not interfere with them for some days; keep the air out, for a wound left in contact with the air suppurates; however, should pain and heat arise, open and wash out again, or even a poultice may be necessary, but do not pull your dressings about — nature works better alone; if first intention fail, she may succeed in the second, as a jeweler, if he can solder gold to gold does so, if not, he has to take to borax; these resources, however, we learn well, not by arguing but by operating. By the new method you will have no stinks, shorter convalescence, and clean, thin scars. In wounds of the neck he says that alterations of the voice suggest implications of the larynx. When using the word "nature," he freely admits that the word is an equivocal one, but he would speak of her allegorically as a lute-player to whose melodies the physician has to dance. Again he says: "Every simple wound will heal without any notable quantity of pus, if treated on Theodoric's and my instructions. Avoid every cause of formation of pus, such as irritating applications, exposure to air, high diet, edema, local plethora. Many more surgeons know how to cause suppuration than how to heal a wound." Now let me remind you that, until Hugh of Lucca, the universal doctrine was that suppuration or coction is necessary; and that if it does not set in, it must be provoked.

The greatest of the French surgeons before Paré was Guy of Chauliac, who flourished in the second half of the fourteenth century. He studied in letters and medicine at Toulouse and Montpellier; in anatomy at Bologna. The surgeon, ignorant of anatomy, he says, "carves the human body as a blind man carves wood." The Arabs and Paris said: Why dissect if you trust Galen? but the Italian physicians insisted on verification. Guy was called to Avignon by Clement VI. During the plague of 1348 he stayed to minister to the victims, and did not himself escape an attack, in which he was ill for six weeks. His description of this epidemic is terrible in its naked simplicity. He gave succor also in the visitation of 1360.

His *Chirurgia Magna* I have studied carefully, and do not wonder that Fallopius compared the author to Hippocrates, and that John Freind calls him the prince of surgeons. The work is rich, aphoristic, orderly, and precise. Guy was a more adventurous surgeon than Lanfranc, as was Franco, a later Provençal, than Paré. He did not cut for stone, but he operated for radical cure of hernia and for cataract; operations till his time left wholly to the wayfaring specialists. In Guy the critical spirit was awake. He scorns the physicians of his day, "who followed each other like cranes, whether for fear or love he would not say." In respect of principles, however, Guy was not infallible. Too sedulous a disciple of Galen, he was as a deaf adder to the new message of Hugh, Theodoric, and Henry; and not only was he deaf himself, but, as the authoritative master of the early renascence, he closed the ears of his brethren and successors, even to the day of Lister.

This vigorous life which surgery gave to the medicine of the thirteenth and fourteenth centuries was stifled in the West by the pride and bigotry which, culminating in the Council of Tours, had thrust surgery down into the ranks of illiterate barbers, reckless specialists, and adventurous charlatans. In Italy, however, the genius and bent of the people for art as well as for philosophy, and the ascendency of the secular element in the universities, still kept surgery in its place as "the scientific arm of medicine." [1] Thus in Italy of the fifteenth century surgery did not droop as it did in the West; if it slumbered for a spell, it soon awoke again, refreshed in the new Hellenism. Pietro di Argelata (d. 1423), Doctor of Arts and Medicine, and professor of Bologna, wrote an excellent *Surgery* full of personal observation; and perhaps for the first time, was frank about his own mistakes. Bertipaglia, another great Paduan professor, flourished a little after Argelata, but was a man of less originality. Argelata followed the lead of Henry and Guy in some bolder adventure in operative work as distinguished from mere wound-surgery, and was himself a learned and skillful practitioner.

In the midst of the mainly Arabist professors of medicine of the fifteenth century arose Benivieni, the forerunner of Morgagni, and one of the greatest physicians of the late Middle Ages. This distinguished man, who was born in 1448 and died in 1502, was not a professor but a Doctor of Medicine, a man of culture and an eminent practitioner in Florence. Although born in the new platonism, he was, like Mondeville, one of those fresh and independent observers who surrender to no authority, to Arab nor Greek. Yet for us Benivieni's fame is far more than all this; for he was the founder of the craft of pathological anatomy. So far as I know, he was the first to make the custom, and to declare the need of ne-

[1] A phrase which Sir John Burden Sanderson once used in my hearing.

cropsy to reveal what he called not exactly "the secret causes," but the hidden causes of diseases. Before Vasalius, Eustachius, or Fallopius were born, deliberately and clear-sightedly he opened the bodies of the dead as keenly as any pathologist in the more spacious times of Morgagni, Haller, or Senac, or of Hunter, Baillie, and Bright. Among his pathological reports are morbus coxae (two cases), biliary calculus (two cases), abscess of the mesentery, thrombosis of the mesenteric vessels, stenosis of the intestine, "polypus" of the heart, scirrhus of the pylorus, ruptured bowel (two cases). He gives a good description of senile gangrene. Thus necropsy was first brought into practice to supplement the autopsy which the surgeon had long practiced in the living subject.

It would be unjust to forget that in the latter half of the fifteenth century Paris admitted some reforms; celibacy for physicians was abolished, and with it diminished the allurements of prebends and rectories, and the pernicious practice of the "médecins reclus" who did not visit patients nor even see them, but received visits from ambassadors who brought gifts and vessels of urine, and carried back answers far more presumptuous than the well-known counsel of Falstaff's physician. Still not only was reform in Paris very grudging, but it was capriciously favored and thwarted by the French court. The faculty denied to St. Come "esoteric" teaching, diagnosis, and the use of medical therapeutics; a jealousy which ended in the physician being requested to do little more than write the prescription. Aristotle was quoted as unfavorable to the "vulgarizing of science." Joubert was attacked for editing Guy in the vernacular. Fortunately the surgeons were carried into the field of battle, a far better school than the Paris Faculty.

Thus it was that in the opening of that great century in the history of the human mind, the sixteenth century, we find Italian medicine still in the van, until the birth of the great French surgeons, Franco and Paré, and of Gersdorff and Würtz in Germany.

Franco, like Paré, was no clerk; he came of a class lower even than that of Paré and the barbers, the wayfaring class of bonesetters, oculists, plastic operators, and cutters for stone and hernia; "runagates," as Gale calls them. Thus dangerous visceral operations, and those on the eye, which but too often were swiftly disastrous, fell into the hands of wandering and irresponsible craftsmen, men of low origin, and too often ignorant, reckless, and rapacious. As the truss was a very clumsy instrument, at any rate till the end of the seventeenth century, the radical cure of hernia was in great demand. It is not the least of the merits of Franco that he brought these operations within the lines of responsible surgery, and thrust them into the ken of Paré and Fabricius. This illustrious Provençal surgeon — "*ce beau génie chirurgical,*" as Malgaigne calls him, in declining the task of entering upon so full a life — was born about 1503. He began as an apprentice to an operating barber and hernia specialist. He had no more "education" than Paré or Würtz, and he was spared the misfortune of a speculative intellect. He picked up some anatomy, educated himself by observation, experience, and manipulation, and as a simple operator or "Master," won considerable renown. As upright and modest as Paré, though he never attained Paré's high social position, he submitted to call in the physician, and took his quiet revenge in the remark that the physicians did not know enough to distinguish good surgery from bad. Nicaise says roundly, "No surgeon made such discoveries as Franco; for hernia, stone, and cataract he did much more than Paré." Whether from incapacity or the brutality of habit, during the Middle Ages and down even to the middle of the seventeenth century, it had been the custom in operating for hernia to sacrifice one or even both testicles, an abuse against which Franco took successful precautions, for he proved that the canal could be closed and the ring sutured without castration. In irreducible inguinal hernia he distinguishes between opening and not opening the sac, and describes adhesions of sac and intestine. From him, indeed, dates the rational operation for strangulated hernia, and in strangulated scrotal hernia he founded the method. Paré, and after him Petit, condemned the ablation of the testicle, which procedure, however, many surgeons thought quite good enough for priests; and Paré gives credit to Franco for these advances, though Fabricius does not even mention them. On the interesting subject of plastic operations, which attained a remarkable vogue in the Middle Ages, and were but restored by Tagliacozzi, I have not now time to speak.

The very eminence of Ambroise Paré encourages if it does not command me to be content with a few words of commemoration. Himself of humble origin, he won for surgery in France a social place and respect it had never attained before. Born in 1517, he became a barber's apprentice in the Hôtel Dieu, whence he followed the campaign of Francis I against Charles V. As he could not write a Latin treatise, his admission to St. Come was of course opposed by the Faculty; but Paré stoutly declared that the vernacular tongue was essential to the progress of medicine. Riolan the elder, who had taken part in the opposition, wrote a tract on the other side, in 1577, with the following insolent title: *Ad impudentiam quorundam Chirurgorum qui medicis aequari et chirurgiam publicè profitere volunt pro dignitate veteri medicinae apologia philosophica.* Now at this time Paré was 60 years of age and surgeon to the King. If in comparison with Paré, Haeser treats Franco somewhat slightingly, and if in some respects Paré may not be lifted far above some of his great Italian contemporaries, such as Maggi, Carpi, or Botallo, yet taken all around the founder of modern surgery surely surpasses all the physicians of his time as an independent, original, and inventive genius, and as a gentle, masterly, and true man. Yet I am often surprised to see, even to-day, the invention of ligature of arteries attributed to Paré, whose surprise, if our journals have an astral shape, must be greater still, seeing that he himself refers the ligature to Galen. The attribution is of course a legend. Malgaigne discreetly claims no more for Paré than the application of the ligature from wound-surgery to amputations; but in my opinion even this claim goes beyond the truth of history. Celsus speaks of the ligature as an ordinary method in wounds; from Oribasius we learn that Archigenes of Apamea even tied vessels in amputation, after fixing a tight band at the root of the limb. It seems probable that, unless performed with modern nicety, secondary hemorrhage must have been frequent; indeed in 1773, Petit deliberately discarded the ligature, as Franco and Fabricius had done before him. Military surgeons considered even Paré's "ligature en masse" too delicate a method for the battle-field. It is a more intelligent service to this great man to point out that the ligature and other operative details were no singular devices, but orderly steps in a large reform of method in amputation, a reform made imperative by the ravages of firearms, ravages which could not be covered up with Galenisms.

It is the privilege of the historian to make light of time and space; and it is not easy to leave Paré and his times without some reflection upon the great German surgeons, Brunschwig, Gersdorff, and Würtz, who, like him, were concerned with the effects of firearms. In Italy in the sixteenth century surgery was somewhat on the wane, but in Germany Würtz, in the freshness and originality of his mind and in his freedom from scholastic convention, reminds us of Paré.

Paracelsus (born 1491) was a surgeon and no inconsiderable one. Had this extraordinary man been endowed with a little patience he would have been a leader in wound-surgery, though, like Würtz, he was not an operator. He pointed out not only the abuse of the suture by the surgeons of the day, but also that suppuration is bad healing, for, if left to herself, nature heals wounds by a natural balm, a phrase which Paré adopted. In his *Grosse Wündarznei* he says he began at the surgical because it is the most certain part of medicine, and time after time he rebukes those who withdraw medicine from surgery. Brunschwig was indeed the first surgeon to write upon the surgery of gunshot wounds with any fullness or precision. He held, however, as Vigo after him, that a gunshot wound was a poisoned wound; and, to eliminate the poison by free suppuration, used the medicated tents, or in case of thorough penetration, the setons which were to arouse the angry antagonism of Würtz.

Felix Würtz, like Franco and Paré, had also the good fortune to escape a scholastic education; he was lucky enough, however, to enjoy the liberal education of Gesner's friendship, and to listen to the fiery disputes of Paracelsus. Gifted with an independent and penetrating mind, he is as fresh and racy as Henry of Mondeville had genius enough to be in spite of the schools. Like all his compatriots, he wrote in the vernacular; and for its originality and conciseness, Würtz's *Practica*, published in 1563, stands in a very small company. Had he known as much anatomy as Paré, his defect in which he bewails, he might have been as great a man, for his clinical advances were both new and important. He protests against the kind of examinations for practice held in some cities where candidates patter off cut and dried phrases like parrots, while apprentices "play upon the old fiddle the old tune continually." By setting his face against cataplasms and grease, he made for progress, though neither he nor Paré attacked suppuration in principle as Theodoric and Henry had done. His chief title to fame, a fame far less ripe of course than that of Sydenham, but, as it seems to me, not unworthy to be remembered beside it, lies in his clinical acumen, and especially in his conception of wound infections and their results. His description of diphtheria is especially remarkable.

While surgeons from generation to generation were making the solid progress I have indicated, what were the physicians about? Now, of the fantastic conceits they were spinning, of the gross and blundering receipts with which they stuffed their books, I have not time to speak; fortunately, history has but too well prepared you to dispense with this side of the story. One example I will give you: In the sixteenth century the air was rent by the clamor of physicians contending in two camps with such ardor and with such acrimony that the Pope, and even Charles the Fifth, interfered — and on what momentous principle? Whether, in such a disease as pleuro-pneumonia, venesection was to be practiced on the same side as the disease or on the opposite side? Brissot, who questioned the Galenical tradition in this matter, was declared by the Emperor to be a worse heretic than Luther. Unfortunately for Imperial medicine, if indifferently for science and the public weal, it came out, on the recovery of the text of Hippocrates, that Brissot had happened to be on the side of the father of medicine.

England, if by England we mean no more than the Isles of Britain, makes no great show in medieval or renascence surgery. Arderne was probably a far better surgeon than Gilbert or John of Gaddesden; but he is little more than a name. Nor does it do to peruse Thomas Gale (1507-1586?) after Mondeville, Guy, Paré, Würtz, or Maggi. In the *Wounds Made by Gonneshot*, the third part of his *Surgery*, lies Gale's merit, that he also withstood "the gross error of Jerome Brunswicke and John of Vigo, that they make the wound venomous."

With the sixteenth century my survey must end; from this time medicine entered upon a new life, upon a new surgery founded on a new anatomy and on a new physiology of the circulation of the blood and lymph. These sciences, thus renewed, not only served surgery directly, but by the pervading influence of the new accuracy of observation, and the enlargement of the field of induction, also indirectly modified the traditional medicine of physicians unversed in methods of research, as we observe in the objective clinical medicine of Sydenham. Our physiologists tell us that destruction is easy, construction difficult; but in the history of medical dogma this truth finds little illustration. So impatient is the speculative intellect of the yoke of inductive research, so tenacious is it of its castles in the air, that no sooner did Harvey, by revealing the mechanics of the circulation, sap the doctrines of the schools, than some physicians instantly set to work to run up the scheme of iatro-physics; others to build a system of iatro-chemics, but upon Von Helmont rather than on Willis and Mayow; while Hoffman and his school resuscitated the *strictum* and *laxum* syllogisms of the Greek Methodists.

In this sketch of the past, a sketch necessarily indiscriminate, but not, I trust, indiscreet, we have seen that up to the time of Avicenna, medicine was one and undivided; that surgery was regarded truly, not as a department of disease, but as an alternative treatment of any disease which the physician could reach with his hands; that the cleavage of medicine, not by some natural and essential divisions, but by arbitrary paltering to false pride and conceit, let the blood run out of both its moieties; that certain diseases thus cut adrift, being nourished only on the wind, dried into mummy or wasted in an atrophy, and that such was medicine; while the diseases which were on the side of the roots, if they lost something of their upper sap, were fed from below, and that such was surgery.

Thus the physicians who were cut off from the life-giving earth, being filled with husks and dust, became themselves stark and fantastic. Broadly speaking, until the seventeenth century pathology was a factitious schedule, and medicine a farrago of receipts, most of them nauseous, many of them filthy; most of them directly mischievous, all of them indirectly mischievous as tokens of a false conception of therapy. A few domestic simples, such as the laxatives, are indispensable; for the rest we are tempted to surmise that mankind might have been happier and better if Dioscorides had been strangled in his cradle.

This is the truth I have tried to get home to you, that in the truncation of medicine the physician lost not only nor chiefly a potent means of treatment; he lost thereby the inductive method; he lost touch with things; he deprived his brains of the coöperation of the subtlest machine in the world — the human hand, a machine which does far more than manufacture, which returns its benefits on the maker with usury, blessing both him that takes and him that gives.

Pure thought, for its own sake, especially in early life, when the temptation to it is strong and experience small, seems so disinterested, so aloof from temptation of gain, that in the history of ideas, speculation and the construction of speculative systems have played but too great a part, and have occupied but too many minds of eminent capacity. We must assume then that they have served —and for aught we know may still serve — some good end. It seems hardly likely that age after age men would busy themselves to build up these vast constructions in idle exercise. That nature is wasteful we know but too well; yet she is wasteful by the way, not in the main direction of her work. If some of her seed falls on stony ground, if her rain falls on the just and on the unjust, yet the sowing and the rain are in the main fruitful and delightful. Peradventure, in our modern conviction of the efficiency of the inductive method we may be too ready to denounce other methods which, hard as it may be for us to conceive, may yet play some lasting part in evolution. Even in our own day we may become too analytical; on our good side we may be too exclusive. In the pale hue even of inductive analysis may we not get sick, lose resolution in too much deliberation, overlook the concrete, and forget that if by any mode of generalization we lose hold of individuals in types, and of things in the negations and eliminations of abstraction we may fall ourselves into the very error of the "school-authors." If the search for entities was false, may there not be a sort of imposition in "laws"? When in the last analysis we attain to unresolved residua may we not err in giving even to a true residuum too solid a name? Whether it be the summation of phenomena or a vision of the imagination an abstraction is an abstraction, and abstractions carry us a long way from deeds and things.

In the minds of academical teachers the notion still survives that the theoretical or university form and the practical or technical form of a profession or trade may not only be regarded separately, and taught in some distinction, which may be true, but in independence of each other; nay, that the intrusion of the technical quality by materializing, degrades the purity or liberality of the theoretical; that indeed if he had not to get his daily bread the high-minded student may do well to let the shop severely alone. Thus the university is prone to make of education thought without hands; the technical school, hands without thought; each fighting shy of the other. But if in a liberal training the sciences must be taught whereby the crafts are interpreted, economized, and developed, no less do the crafts, by finding ever new problems and tests for the sciences, inseminate and inform the sciences, as in our day physics are fertilized by the fine craft of such men as Helmholtz, Cornu, and Stokes; and biology by that of Virchow, Pasteur, and Lister. At the commemoration of Stokes in Westminster Abbey, Lord Kelvin honored in him the "combination of technical skill with intuition;" and Lord Rayleigh admired in him "the reciprocity of accurate workmanship and instinctive genius;" appreciations no less true of these two distinguished speakers themselves. If it be true, as I have been told, that the University of Birmingham has a coal-mine upon the premises, I am ready to believe that the craft of coal-getting, by carrying practice into thought, will fortify the web of theory.

There exists, no doubt, the contrary danger of reducing education to the narrow ideas and stationary habits of the mere artisan. By stereotyped methods the shop-master who does not see beyond his nose, may cramp the 'prentice, and this 'prentice becomes shop-master in his turn. If in the feudal times, and times like them in this respect, manual craft was despised, and the whole reason of man was driven into the attenuated spray of abstract ingenuity, in other times or parts of society a heavy plod of manual habit so thickened "the nimble spirits in the arteries" that man was little better than a beaver: on the one side matter, gross and blockish; on the other, speculation vacuous of all touch of nature. We need the elevation, the breadth, the imagination which universities create and foster; but in universities we need also bridges in every parish between the provinces of craft and thought. Our purpose must be to obtain the blend of craft and thought, which, on the one hand, delivers us from a creeping empiricism, on the other, from exorbitant ratiocinations. That for the progress and advantage of knowledge the polar activities of sense and thought should find a fair balance, is set forth judicially enough in modern philosophy, and is eminent in great examples of mankind. Moreover, it is apprehended in the reciprocal tensions of faith and works, of hypothesis and experience, of science and craft. In our controversies on theory and practice, on universities and technical schools, on grammar and apprenticeship, we see their opposite stresses. The unison is far from being, as too often we suppose, one merely of wind and helm, it is one rather of wind and wing; it consists not in a mere obedience of hand to mind, but in some mutual implication, or generative conjugation of them. How these two forms of impulse should live in each other, we see in the Fine Arts — in the swift confederacy of hand and mind in Dürer, Michael Angelo, Rembrandt, Velasquez, Watteau, Reynolds. The infinite delicacy of educated senses is almost more incredible than the compass of imagination. When they unite in creation no shadow is too fleeting, no line too exquisite for their common engagement and mutual reinforcement. Michael Angelo and Leonardo da Vinci, the greatest craftsmen perhaps the world has seen, were as skillful to invent a water-engine, to anatomize a plant, or to make a stonecutter's saw, as to build the dome of St. Peter above the clouds of Christendom.

Solve the problem as hereafter we may, now we can take heed at least that energy shall not accumulate about one pole or the other. Our little children have a message to us if we would but hearken to them. Every moment they are translating action into thought and thought into action. Eye, ear, and hand are incessantly on the watch and in pursuit, gathering incessantly for the mind and the forms of thought which as rapidly issue again in new activities. If, as we mature, we gain the power of restraint, it is not that we shall cease to act, that the mind shall depose the hand, but that these variables shall issue in a richer and richer function. If we forget the hands, that cunning loom which wove our minds, if thrusting them into our pockets, we turn our eyes inwards, will our minds still truly grow? That by virtue of the apposable thumb monkey became man is no metaphor; in its measure it is sober truth. For the last millennium too much thinking has been the bane of our profession; we have actually made it a point of honor to ignore the hands out of which we were fashioned, and in this false honor to forget that the end of life is action, and that only by action is action bred. While we profess to admire Bernard Palissy or Jean Goujon, the medieval mason or the medieval goldsmith, we act nevertheless as if fine arts only are honorable, and mechanical arts servile; whereby we blind ourselves to the common laws of growth, which, knowing not these distinctions, deal out barrenness to those who make them. We begin even with our children to wean them from the life of imaginative eyes and of thoughtful fingers; and instead of teaching them to rise from simple crafts to practical crafts, to scientific crafts, or to lovely crafts, and thus to pursue the mean of nature herself, we teach them the insolence that, except in sports, the mind should drop the acquaintance of the fingers.

Shall we wonder then that in this generation bold men call English people stupid; all stupid save those few men of genius or rich talent who, like Gilbert, Harvey, or Darwin, were great enough to be true to eye and hand, and to breed great conceptions by their intimate coition with the mind? Shall we wonder then that medicine fell into sterility when by most unnatural bonds surgery, her scientific arm, was tied behind her, and her sight was turned inwards from processes to formulas? Shall we wonder that even in the eighteenth century, when medicine had begun tardily to occupy itself in the crafts of pathology and chemistry, one visionary after another, striding in long procession athwart the barren wilderness of physic, wasted his generation in squeamish evasion of the things that happen, and in vain pursuit of vacuous unities? Yet, if to the high stomachs of our forefathers surgical dabblings were common and unclean, still there remained some eyes curious enough and some fingers dexterous enough to carry the art back to the skill of Hippocrates, and forward to the skill of Lister; but it was by the mouths of barbers and cutters, rather than of the pharisees of the colleges, that medicine breathed her lowly message to her children.

THE PROBLEMS OF INTERNAL MEDICINE

BY WILLIAM SYDNEY THAYER

[**William Sydney Thayer**, Professor of Clinical Medicine, Johns Hopkins University, Baltimore, Maryland; Associate Physician, Johns Hopkins Hospital, *ibid.* **b.** Milton, Massachusetts, June 23, 1864. A.B. Harvard, 1885; M.D. *ibid.* 1889; studied in Vienna, Berlin, and Paris; House Physician, Massachusetts General Hospital, 1888–89; Resident Physician, Johns Hopkins Hospital, 1891–98; Associate in Medicine, Johns Hopkins University; 1895–96; Associate Professor of Medicine, *ibid.* 1896–1905; Visiting Physician, Union Protestant Infirmary. Member (Honorary) of Therapeutical Society of Moscow; Association of American Physicians; Medical and Chirurgical Faculty of Maryland; American Association of Pathologists and Bacteriologists; Washington Academy of Sciences; American Academy of Arts and Sciences. **Author** of *The Malarial Fevers of Baltimore* (with John Hewetson); *Lectures on the Malarial Fevers.*]

To recognize, to prevent, to protect, to heal — these are, in the broadest sense, the tasks of internal medicine now as ever. But how different are the problems which occupy our attention to-day from those of the period commemorated by this Congress. Let us for a moment glance back at the medicine of the close of the eighteenth and the beginning of the nineteenth centuries. For over two hundred years the blind and binding faith of the Middle Ages, the faith that had so long fettered the human mind, had been slowly giving way before the forces of reason and truth. Now and again with ever increasing frequency, great and courageous minds had risen above the clouds of medical tradition and dogma which had smothered the understanding and reason of mankind, as if, indeed, medicine were a part of the religious doctrine which ruled the world. For truly the medicine of the Middle Ages was largely a matter of faith, and as a matter of faith one in which reason beyond a certain point was heresy and sacrilege. Vesalius with genius and courage had begun to withdraw the veil from naked and iconoclastic truth. Harvey had made his great discovery. Glisson had demonstrated his theory of irritability. Mayow, with his "Spiritus nitroaëreus," had anticipated the discovery of oxygen. Leeuwenhoek and Malpighi and Hooke had opened to the human eye the realm of the infinitely small. Bacon and Descartes and Newton and Locke had introduced into the world a rational and natural philosophy. Locke, himself indeed a wise physician, had pointed clearly to the true path of medical progress. "Were it my business," says he, "to understand physick, would not the safer way be to consult nature herself, in the history of diseases and their cures, than espouse the principles of the dogmatists, methodists, or chymists?"

But the clouds of medical tradition were slow to clear away.

Gradually, however, the first "lonely mountain peaks of mind" were followed by an ever increasing number of earnest and untrammeled students. In the seventeenth century the opportunity to give one's life freely to the search for truth had become more and more open to all. The mysticism and animism of Stahl, which, in the early part of the eighteenth, hung over the medical world, was already breaking away. The study of the natural sciences was pursued more eagerly and generally than ever before. Réaumur and Black and Haller and Spallanzani and Hunter and Priestley and Lavoisier had lived. Morgagni, sweeping aside the dogmatism of the old schools, had demonstrated the local changes in many diseases and had opened the way for the objective pathological anatomy of Bichat. In the field of practical medicine such men as Sydenham and Morton and Torti and Lancisi practiced and taught much which holds good to-day. Boerhaave had introduced clinical instruction. Cullen and Cheyne and Huxham and Pringle and Heberden and Van Swieten and De Haen were all in many ways true and faithful students; yet methods and doctrines that were often strangely fantastic still held general sway — such, for instance, as the Brunonian system. A perusal of the writings of Stoll, one of the wisest practitioners of his day, cannot fail to impress one with the meagerness of the basis of anatomy and physiology, normal and pathological, on which medicine rested, the almost entire lack of diagnostic methods, the absence of a rational therapy — how much of the conjectural, how little of the scientifically exact there was in medicine.

Diagnosis, based largely upon gross clinical conceptions, was necessarily vague and uncertain.

Prophylaxis, in the absence of any certain knowledge of the causes and manner of origin of disease, was devoid of any sound basis.

Treatment was almost wholly empirical, and, where it was not empirical, it was frequently based upon some theoretical system so arbitrary and dogmatic that the unfortunate sufferer was too often stimulated or purged, fed or bled, as he fell into the hands of a Brown or a Broussais, rather than according to the nature of his malady.

In the Dictionnaire de l'Académie française for 1789, a year which marks the end of an era in the world at large, one finds the following definition: "Médecine. *s. f.* L'art qui enseigne les moyens de conserver la santé & de guérir les maladies. (La médecine est un Art conjectural. * *)" Medicine a conjectural art! Such was the estimate placed upon our profession by the French Academy a little over one hundred years ago.

But the seeds of a new life had been sown and the germination had already begun. Even as these words were written Lavoisier, too soon to fall a victim to the premature explosion of the forces of pent-up freedom, was in the midst of his great work. In 1796 came the introduction of vaccination by Jenner, and but a few years later, Bichat with his wonderful genius, took up the thread dropped by Morgagni and placed anatomy and physiology, normal and pathological, on a basis of accurate observation and experiment. Hand in hand with the introduction of exact methods of anatomical and physiological observation, Auenbrugger, in 1761, had demonstrated in his *Inventum Novum*, a method of physical investigation which, for the first time, enabled the physician to determine changes in size, shape, and consistency of the thoracic organs. At first unnoticed by the world, this important discovery was destined to gain a sudden general recognition in the early days of the nineteenth century. With the spread of knowledge of the gross pathological changes in disease which followed the inspiration of Bichat, the work of Auenbrugger, expounded by Corvisart, became a common possession of the medical world, and, less than ten years later, Laënnec, by the introduction of mediate auscultation, opened possibilities for accurate physical diagnosis such as had not been dreamed of in the ages which had gone before.

With the great school of French observers which followed Laënnec, Andral, Chomel, Louis, Bouillaud, and Trousseau, with Skoda and Schönlein in Germany and Addison and Bright and Stokes in England, the exact association of clinical pictures with local anatomical changes made great advances. Typhus and typhoid fevers were distinguished; the relation between albuminuria and renal disease was demonstrated; the association of endocarditis with acute rheumatism was discovered; the corner-stone of our knowledge of cerebral localization was laid. Clinical diagnosis was becoming more than a conjectural art.

In the mean time physiology was making great strides. Majendie, Bell, Johannes Müller, Beaumont and finally Claude Bernard, and a host of their followers, were shedding light upon many obscure corners of our knowledge of the vital functions. In the hands of Müller the microscope began to open up new fields of study which were destined in a few years through the cultivation of the genius of a Virchow and a Max Schultze to bear a noble harvest. The "great reform in medicine" which followed the introduction of the cellular pathology laid solid foundations for much which is most vital in our anatomical and physiological and pathological knowledge of to-day, and the correlation of these observations with the results of accurately recorded clinical studies, the application of the microscope to the study of the urine, the sputa, the blood, to pathological neoplasms, to exudates and transudates, soon brought new material for the rising edifice of a rational, exact diagnosis. The sphygmograph, the thermometer, the ophthalmoscope, the laryngoscope, the binaural stethoscope, the stomach tube, the various means for studying the blood-pressure, all have brought their aid, while but yesterday the discovery of Roentgen has given us new and unhoped for diagnostic assistance.

At the same time physiological chemistry which, with the work of Berzelius on the urine, had taken its place by the side of the more purely physical methods of investigation, has year by year given us greater diagnostic assistance in the analysis of the different secretions and excretions of the body and in the explanation of the various metabolic processes of the economy.

The development in the hands of Duchenne and Erb and Remak of electrical diagnosis, together with the great advances in physiology and pathology of the nervous system, has afforded explanation for much that was previously incomprehensible and has given us powers of diagnosis which a few generations ago would have seemed almost magical.

Finally Pasteur and Koch, with the introduction of bacteriological investigation, opened the way to the discovery of the causal agents of a large group of infectious diseases. These discoveries, followed rapidly by the evolution of methods allowing of the clinical demonstration of many pathogenic microörganisms, afforded an early, exact, and positive diagnosis, on the one hand in conditions where previously the disease was recognizable only at a stage in which it had made inroads into the system so great as to be often beyond relief, as in tuberculosis, and on the other, in maladies, the existence of which without these methods was to be definitely determined only after the onset of an epidemic, as in cholera, plague, and influenza. When one thinks of what the last quarter of a century has taught us with regard to tuberculosis, anthrax, tetanus, diphtheria, typhoid fever, cholera, plague, dysentery, influenza, not to speak of the great group of wound-infections, we may begin to realize what bacteriological methods have done for diagnosis — how many diseases have been cleared up — how many symptoms have been explained.

In like manner Laveran, with the discovery of the parasite of malarial fever, did much to bring certainty and precision into a field in which many had gone astray, while opening the way for the important observations of Theobald Smith and all the knowledge which we have gained in recent years with regard to the hematozoa of man and animals.

As a direct result of the introduction of bacteriological methods, the study of the manner of action of infectious agents and their toxic products upon the animal organism, as well as of the powers of resistance of the economy against infection, has given us, with the discovery of specific agglutinines and precipitines, diagnostic methods of the greatest value, not only for the recognition of various infectious processes, but for the identification of specific sera, affording in particular a test for human blood destined (probably) to prove, when properly applied and interpreted, of great medico-legal value.

This is indeed a gain over our knowledge of one hundred years ago. In how many fields has the conjectural given way to the exact! At the end of the eighteenth century the diagnostic effort of the physician, unaided by instruments of precision or even by the simplest physical methods of auscultation and percussion, was directed toward the detection of gross anatomical changes. To-day with our increased knowledge of anatomical, physiological, and pathological processes, with our growing insight into the chemical and physical features of vital activity, our duty no longer ends in the recognition of physical changes in organs, in the determination of the presence of a specific lesion or infection; it is further our task to search for the earliest evidence of disturbance of function, which may later lead to grosser, more evident change, to separate the physiological from the pathological, to estimate, as far as may be, the power of resistance of the different organs and tissues and fluids of the body to insults of varying nature, to determine the functional capacity of a given organ — its sufficiency or insufficiency. In addition to increasing opportunities in the field of pathological anatomy we find ourselves drawn further into the study of pathological physiology — and knowledge in the field of pathological physiology leads of necessity to power in functional diagnosis.

It must be acknowledged that with regard to many organs the determination of the limits of functional power and the estimation of the degree of impairment in disease are matters most difficult to appreciate, yet with improved methods and persistent research, progress is being made.

We are, after all, but beginning to realize a few of the possibilities before us, but even this is a step in advance which holds out no little promise for the future and offers new and tempting opportunities for study and investigation.

At the end of the eighteenth century but three important, rationally conceived measures of prophylaxis had been practiced — the dietetic measures of protection from scurvy, the older inoculation and Jenner's great contribution of vaccination against small-pox. It was not, indeed, until the development of bacteriology that prophylaxis took its place as a scientifically exact branch of medicine. The recognition of the specific cause of many infectious diseases, the knowledge of the life-history of the pathogenic micro-organisms, the discovery of the portals through which they gain entrance to the animal economy, and the conditions under which infection occurs, have brought to us material powers to prevent and protect. The first great result of this new knowledge was the development of antiseptic surgery and all that it represents. But apart from this we have but to remember what has been gained by a scientifically evolved prophylaxis against tuberculosis and typhoid fever — to reflect upon how far cholera and plague have lost their terrors — to contemplate the brilliant results of the discovery by Ross and the Italian school of the life-history of the malarial parasites as manifested in the anti-malarial campaigns carried on in various regions by Koch, and in Italy by the Society for the Study of Malaria, a noble institution, of which our Latin brothers may well be proud, and lastly to look upon the beneficent and far-reaching influence of the recent work of Reed and Lazear and Carroll and Agramonte with regard to yellow fever, to realize what bacteriological and parasitological studies are doing for preventive medicine.

But beyond this external prophylaxis, the studies of the problems of immunity, beginning with Pasteur's inoculations against anthrax in 1881, have given us, so to speak, an internal prophylaxis, a functional prophylaxis, if one will, in the possibility of producing a greater or less degree of individual immunity, such, for instance, as is now possible in diphtheria, cholera, plague, typhoid fever, and dysentery.

The enforcement of scientifically planned and accurately deduced prophylactic measures has become to-day one of the main duties of the practitioner of medicine. It is as much the task of the physician nowadays to guard over the disposal of the sputa of his tuberculous patient, of the excreta of the sufferer from typhoid fever, or cholera, or dysentery, as it is to attend to the immediate wants of the invalid. How rapidly has the exact replaced the conjectural in this branch of medicine!

But while diagnosis and prophylaxis were being removed from the domain of conjecture to the field of exact observation, and reason, and research, while the possibilities of surgery were rapidly widening through the discovery of anesthesia and the introduction of antiseptic methods, medical treatment, until the last two decades, still remained largely empirical. The development of exact clinical methods of observation and the statistical tabulation of experience for which we are especially indebted to Laënnec and Louis, and their followers, gradually brought about, to be sure, many advances, while a large number of useful therapeutic agents introduced by the newly developed science of pharmacology, and exactly tested by improved methods of physiological study, added greatly to the armamentarium of the physician for the relief of symptoms. The power to combat disease specifically, however, remained much as it was at the beginning of the century. Mercury in syphilis, quinine in malarial fever, were the only specifics known to the medical world — and the action of these was unexplained.

The introduction by George Murray, less than fifteen years ago, of the treatment of myxedema and allied conditions by extracts of the thyroid gland, was a direct application of the results of physiological observation to the treatment of disease. If this gave rise to hopes of the possibility of obtaining like results from roughly obtained extracts of other ductless glands, which have hardly been fulfilled, yet the discovery was the first step toward the rational scientific therapy to which we are beginning to look forward to-day.

But a moment ago I spoke of the importance of the influence of the discovery of the causal agents of the infectious diseases upon the development of exact diagnostic and prophylactic methods. Great and impressive as these have been, yet the studies which have followed as to the manner in which these agents act upon the human organism, and of the powers of resistance which the body exerts against them, the investigation of the problems of immunity have opened out a far wider field. The early studies of Metchnikoff and Buchner and Nuttall were followed with rapidity by the epoch-making work of Behring and Kitasato and Roux with regard to tetanus and diphtheria. The diphtheria and tetanus antitoxins were not chance discoveries of empirically determined virtue, but true specific, therapeutic agents, the results of experiment scientifically planned and carefully prosecuted. Widespread investigations of the various phases of immunity, bacterial and cytotoxic, have given us in a few short years a mass of physiological knowledge, the full import of which is scarcely yet to be comprehended. Few things in modern medicine are more impressive than a survey of the work of the last twelve years done under the inspiration of Ehrlich.

Beside the antitoxins of diphtheria and tetanus and the power of producing a greater or less degree of immunity, as has already been mentioned, by preventive inoculations against cholera, plague, and typhoid fever, we have come to possess a bactericidal serum of a certain value in combating the actual disease, plague, while the favorable influence of Shiga's anti-dysenteric serum seems to be undoubted. There is much reason to hope that the recently promised anti-crotalus serum of Noguchi as well as the anti-cobra serum of Calmette may prove to be real boons to humanity. But it is not alone in the production of specific anti-sera that the therapeutic value of the modern studies of immunity lies. There are signs which justify us in looking forward to the possible discovery of an explanation of the mode of action of substances long empirically used, knowledge the value of which may be readily appreciated.

When we consider these facts it is indeed easy to appreciate to what an extent the exact has driven the conjectural from this last field of medicine. A hundred years ago we were depleting and purging and sweating and bleeding according to theories often strangely lacking in foundation, the prevalence of which depended rather upon the individual force and vigor of the expounder than upon their intrinsic merit. To-day from the study of the pathological physiology of bacterial and cytotoxic intoxications, we are rapidly evolving scientific preventive and curative measures, while searching out the rationale and mode of action of our older therapeutic agents.

But a few days ago, I happened to open a copy of Littré [1] bearing, by a curious chance, the date of 1889, and read "Médecine (mé-de-si-n). 1°. Art qui a pour but la conservation de la santé et la guérison des maladies, et qui repose sur la science des maladies ou pathologie" — an essential modification of the definition of one hundred years before and indicative of the changes of a century.

To meet the manifold problems of to-day, the training of the physician must of necessity be very different from what it was a hundred years ago. The strong reaction which set in in the earlier part of the nineteenth century against philosophical generalization in medicine, the insistence upon a strict objectivity, all the more emphatic because of the prevalence of anatomical methods of research, have held very general sway. Medicine, no longer resting upon a basis of philosophical speculation, stands upon the firmer foundation of the exact natural sciences. Almost from the beginning the student of to-day is taught methods, where a hundred years ago he was taught theories. The enormous expansion of the field which must be covered has led naturally, not only to an ever increasing specialism, but to the fact that the course of study which is regarded as properly fitting the physician for practice is reaching backward farther and farther into the earlier years of his school training. On the other hand, in this country at all events, there is heard a common cry that the academic medical training is extending over into years which should be given to practice; that the expense and duration of a medical education, so-called, will soon be such as to shut out from the profession many a man who might be a useful physician and perhaps a valuable contributor to the world's knowledge. To remedy this it is advised that the prospective student of medicine should be led from the earliest stages of his training through the paths of exact research into the domain of the natural sciences to the greater or less exclusion of the classics — the old-time humanities,

[1] *Dictionnaire de la langue française.*

the study of which, useful as it may be from a standpoint of general mental training, is believed by many to be time wasted in the education of the student destined for a scientific career.

But there are not wanting voices which question the wisdom of the full extent of some modern tendencies. May the affectation of too strict an objectivity bred though it may be of a wholesome skepticism, the more general cultivation of the natural sciences to the exclusion of the humanities, the search for facts and facts alone, circumscribe the powers of synthetical reasoning without which the true meaning of many an important problem might pass unnoticed? May they perhaps tend to smother the development of minds capable of grasping large general problems? Do the tendencies of the times justify the epigrammatic observation of a recent French author: "Autrefois on généralisait avec peu de faits et beaucoup d'idées; maintenant on généralise avec beaucoup de faits et peu d'idées"? [1]

That the cultivation of a strict objectivity in research has materially impaired our powers of reason — that the exact methods, which are largely responsible for the enormous advances of the last fifty years in all branches of medicine, have bred a paucity of ideas, I am not inclined to believe, despite the seductive formula of our Gallic colleague. But that when in the period of so-called secondary education it is proposed to *substitute* the study of the natural sciences for a good training in the humanities, there is danger of drying-up some of the sources from which this very scientific expansion has sprung, seems to me by no means impossible. The study of the classics, an acquaintance with the thoughts and the philosophies of past ages, gives to the student a certain breadth of conception, a stability of mind which is difficult to obtain in another way. A familiarity with Greek and Latin literature is an accomplishment which means much to the man who would devote himself to any branch of art or science or history. One may search long among the truly great names in medicine for one whose training has been devoid of this vital link between the far-reaching radicles of the past and what we are pleased to regard as the flowering branches of to-day. Greek and Latin are far from dead languages to the Continental student. They are dead to us because they are taught us as dead. With methods of teaching in our secondary schools equal to those prevailing in England and the Continent, it would be an easy matter in a materially shorter period, to give our boys an infinitely broader education than they now receive. There should be much less complaint of time wasted, much less ground for suggesting the abandonment of the study of branches which are invaluable to any scholarly-minded man.

The assertion that the time spent in the study of the humanities

[1] Eymin, *Médecins et Philosophes*, 8°, Lyon, 1903-4. no 4

results in the end in the encroachment of the academic training upon a period which should properly be given to one's life-work is, it seems to me, often based on an old idea — founded all too firmly, alas, on methods that yet prevail in many of our medical schools — that with his degree in medicine the student has finished a theoretical education, that he must now spend five or ten years in acquiring experience — at the expense, incidentally, of the public — before he can enter into his active life; that, therefore, unless some other branches of early instruction be sacrificed to courses leading more directly to medicine, so that he may enter upon his strictly professional education at a period considerably earlier than is now the case, the physician of to-morrow will become self-supporting only at a period so late in life as to render a medical career impossible to other than those well supplied with the world's goods. With proper methods of instruction this is a wholly false idea. Under fitting regulation of our system of medical training, with due utilization of the advantages offered by hospitals for clinical observation, the experience necessary to render a man a safe and competent practitioner should not only be offered, but required for a license to practice; and even if the length of the strictly medical curriculum be extended one or two years beyond that which is at present customary, it will not be time lost. If one but look around him he will find, I fancy, that few men who have had such a training wait long before finding opportunities for the utilization of their accomplishments; the public in most instances soon recognizes the man of true experience.

But there is yet another side of the question which has hardly been sufficiently emphasized, a side of the question which must come strongly to one's mind when one considers the general education of many of the men who are entering even our better schools of medicine, a point of view which has been especially insisted upon by a recent French observer. A large part of the success and usefulness of the practitioner of medicine depends upon the influence which he exerts upon his patients — upon the confidence which he infuses — upon his power to explain, to persuade, to inspire. It can scarcely be denied that these powers are more easily wielded by the man of general culture and education than by one of uncouth manner and untrained speech however brilliant may be his accomplishments in the field of exact science. I can do no better than quote the words of Professor Lemoine: "C'est qu'en effet l'action morale qu'il peut exercer sur le malade, et qu'il exerce d'autant plus qu'il est supérieur par son intellectualité, est un des principaux éléments de guérison. On guérit par des paroles au moins autant que par des remèdes, mais encore faut-il savoir dire ces paroles et présenter une autorité morale suffisante pour qu'elles entraînent la conviction du malade et remplissent le rôle suggestif qu'on attend d'elles. Ne fut-ce que pour cette raison, je me rangerai parmi ceux qui demandent le maintien d'études classiques très fortes comme préparation à celles de la médecine, car le meilleur moyen de rehausser le prestige du médecin c'est encore de l'élever le plus possible au dessus de ses contemporains." [1]

These words express, it seems to me, a large measure of truth. May it not be that in the tendency to the neglect of the humanities we are taking a false step? May it not be that if, on the other hand, we teach them earlier and better, we shall find in the end that no essential time is lost, while we shall gain for medicine-men not only with minds abler to grasp the larger and broader problems, but with materially fuller powers for carrying on the humbler but no less important duties of the practitioner of medicine?

In that which I have just said I have touched upon the necessity of the requirement of a considerable amount of clinical experience as an essential for the license to practice medicine. To meet the enormously increased demands of the present day, medical education has become, of necessity, much more comprehensive, and must therefore extend over a longer period of time. The methods of research, anatomical, physical, chemical, which the student must master, the instruments of precision with which he must familiarize himself, are almost alarmingly multifarious; and experience in the application of these methods and in the use of these instruments demands increased time. Many of these proceedings, it is true, the physician will rarely be called upon to use personally in practice, for such measures must in great part be carried out by special students or in laboratories provided by the Government. Nevertheless with their significance and value he must be familiar — familiar from personal observation and experience.

But after all there are few diagnostic signs in medicine, and not so many of the improved methods of clinical investigation yield diagnostic results, while to familiarize one's self with methods and instruments of precision is a very different matter from acquiring real experience and skill as a diagnostician or a therapeutist. It is only by gathering together and carefully weighing all possible information that one is enabled to gain a proper appreciation of the situation and to approach a comprehension of many conditions of grave im-

[1] Indeed the moral influence which he (the physician) is capable of exercising upon the patient and which he exercises to an ever increasing degree with his intellectual superiority, is one of the most important of therapeutic agents. One heals by words at least as much as by drugs, but one must know how to *say* these words and to exercise a sufficient moral authority, that they may bring conviction to the patient and carry the full weight of suggestion which is intended. Were it but for this reason I shall range myself among those who demand the maintenance of extensive classical studies as preparation for those of medicine, for the best means to uphold the prestige of the physician is still to raise him as far as possible above his contemporaries. *Congrès français de médecine*, VI Session, Paris, 1902, 8°, t. II, p. xli.

port to the patient. And in forming a sound judgment with regard to these vital questions, that which comes from experience in the close personal observation of the sick is far the most important element. Bedside experience constitutes to-day, as it always has, and always will, the main, essential feature in the training of the physician. But this experience, if it is to bear its full fruit, must be afforded to the student at a time when his mind is still open and receptive and free from preconceived ideas — under conditions such that he may be directed by older trained minds into proper paths of observation and study, for few things may be more fallacious than experience to the prejudiced and the unenlightened.

That such experience may be freely offered to the student there is a grave necessity for a more general appreciation by institutions of medical training as well as by the powers in control of public and private hospitals and infirmaries, of the mutual advantages to be gained by a cordial coöperation. It must be acknowledged that, in this country at least, despite the cultivation of improved methods of clinical investigation, there still prevails in the mind of the public the perverted idea that this bedside observation, this application of new methods of research and study are for the advantage of the student or in the interest of general science rather than for the benefit of the sufferer himself. It must further be recognized that a wholly mistaken conception of the true function of a hospital is widely prevalent. It is all too common to see large and ornate institutions with every arrangement for the comfort and even luxury of the patient, with a medical staff utterly insufficient in number or training to study properly the individual case, not to speak of carrying on scientific investigations. The service, usually under the direction of a busy driven practitioner with barely time to make a short daily visit — large wards under the direct control of one or two young men whose time is wholly occupied by routine work — every care taken for the present comfort of the patient — little provision for enlightened study or treatment of his malady — no opportunities for a contribution on the part of the institution to the scientific progress of the day. Better far for the sufferer were he in the dingy ward of an old European hospital where he might be surrounded by active, inquiring minds recording the slightest changes in his symptoms, ever ready to detect, and as far as the power in them lies, to correct the earliest evidences of perversion of function. What our hospitals need is men, students, whether or no they have arrived at the stage in their career — which, after all, is but a landmark, not a turning-point — that entitles them to the right of independent practice, the enthusiastic, devoted student who, in watching and studying the patient, is contributing alike to the interests of the sufferer, the hospital, and himself.

The three main functions of a hospital — the care of the sick, the education of the physician, the advancement of science — are not to be met alone by building laboratories and operating-rooms and lecture-halls, by furnishing the refinements of luxury to the patient, useful adjuvants though these may be. What the hospital mainly needs is men, men to study and think and work — *students of medicine.*

It cannot be denied that in this respect we in America are behind our cousins of the Old World. Despite our many honorable achievements, the part which we are taking in the modern study of the physiology of disease is still not what it should be.

Ere long we must come to realize that our duty to the sick man consists in something more than to afford him that which most sick animals find for themselves — a comfortable corner in which he may rest and hide from the world; that our duty to the public is to give them as physicians, men of the widest possible general training, ready to enter upon independent practice with an experience sufficient to render them safe public advisers; that our duty to ourselves is to miss no opportunity for the study of pathological physiology at the bedside of the patient; that the accomplishment of these ends depends in great part upon the appreciation by our universities and hospitals of the mutual advantages of coöperation in affording every opportunity for the scientific study of disease while offering to the patient the privileges of enlightened observation and care.

But there are everywhere signs of a future rich in achievement. An improving system of medical education, the increasing opportunities for scientific research offered as well by the generosity of private citizens as by the wisdom of state and national governments, the community of effort which results from closer fellowship among students of all nations, are omens of great promise. The remarkable developments of the last twenty years in all branches of the natural sciences have brought a rich store of suggestion and resource for application in our laboratory, which is at the bedside of the patient. Let us look to it that our clinical methods keep pace with those which are yielding so abundant a harvest in these neighboring fields of scientific research.

SECTION F—NEUROLOGY

SECTION F—NEUROLOGY

(*Hall* 13, *September* 22, 3 *p. m.*)

CHAIRMAN: PROFESSOR LLEWELLYN F. BARKER, University of Chicago.
SPEAKER: PROFESSOR JAMES J. PUTNAM, Harvard University.

THE VALUE OF THE PHYSIOLOGICAL PRINCIPLE IN THE STUDY OF NEUROLOGY

BY JAMES JACKSON PUTNAM

[**James Jackson Putnam**, Professor of Diseases of the Nervous System, Harvard Medical College, since 1893. **b.** Boston, Massachusetts, October 3, 1846. A.B. Harvard, 1866; M.D. Harvard Medical School, 1869. Physician, Massachusetts General Hospital, 1874; Instructor in Diseases of Nervous System, Harvard Medical College, 1875–93. Member of the American Academy of Arts and Sciences; American Medical Association; American Neurological Association; Association of American Physicians and Surgeons; American Association for Advancement of Science; Massachusetts Medical Society; Boston Society of Medical Sciences; Boston Society of Psychiatry and Neurology; Boston Society for Medical Improvement. **Author** of numerous medical publications, mainly on neurological subjects.]

THE subject of this address will be considered under three heads: 1. The limitation in usefulness of those methods of medical investigation which are based on the assumption that disease is always a localized process. 2. The importance of the part played in disease by readjustment and adaptation on the part of the organism, and the need of cultivating physiological conceptions as a means toward a proper understanding of these processes. 3. The impropriety of attempting to draw fundamental distinctions between "functional" and "organic" disorders, and the significance of the hypothesis of "energies" as applied to living organisms and to disease.

When the late Professor Virchow was chosen to deliver the opening address before the International Congress at Rome, in 1894, he selected for his topic "The Anatomical Principle in the Study of Disease" (*Morgagni und der Anatomische Gedanke*"),[1] a doctrine to the maintenance of which a great portion of his own long and splendid labors had been devoted. The anatomical principle was not conceived by Virchow in any narrow spirit. Its tenets were that disease is always a localized process, and ought to be susceptible of expression in some sort of anatomical terms, but he as-

[1] *Berl. kl. Woch*, 1894.

serted that the search for this process might be made as properly through the clinical examination of the patient by the trained physician, together with a careful study of his history, as through the scalpel and microscope of the anatomist. He admitted that the time was still far distant when we should be able to discover the whole of the anatomical evidence, and urged that the inquiry should be extended from the organs to the tissues, and from the tissues to the cells, and even to the very "vital functions" themselves. But he insisted, nevertheless, that in some sense — a sense not as yet strictly defined or definable — every disease was to be thought of as occupying circumscribed areas, in the midst of tissues for the most part or in great part sound. "*Ubi est morbus ?*" — "Where is the diseased spot to be found?" — was proclaimed as the watchword of the investigator, while at the same time the students of therapeutics were congratulated on having found means, as a result of anatomic discoveries, to carry local treatment to portions of the body hitherto regarded as out of reach.

It is needless to attempt a recital of the successes which have been won under this banner of anatomical research. The principle which the great master Virchow proclaimed was one that had appealed and still appeals alike to the faithful plodder and to the man of genius; its history is the best part of the history of medicine during the past half-century; it has been the best thread of guidance since the history of medicine began.

The value of the anatomical principle has been quite as evident for the department of neural pathology as for any other, and the devotion to its maintenance quite as strongly marked. At the meetings of neurological societies the pathologic anatomists have always been more certain of an attentive hearing than investigators of any other sort; in the direction of their work has seemed to lie the sure and trusted path of progress toward a better understanding and a better treatment of disease.

And yet, in spite of all that has been accomplished, there are abundant reasons for the opinion that the very successes of the anatomical principle have thrown unduly into the shade the claims of another mode of approaching the problem of disease, without the aid of which anatomical research must prove inadequate to the task which has been imposed upon it. For this latter principle, which emphasizes the importance of recognition, in disease, the signs of more or less widespread modifications of function of the organism as a whole, the designation of "physiological principle" is appropriate.[1]

[1] There has been a growing tendency to recognize the importance of this standpoint, and very recently Professor Wolkow, of St. Petersburg, has devoted an able and thoughtful essay to a series of considerations analogous to those here offered. *Die Physiologische Anschauung in der Klinischen Medicin, Berliner kl. Woch*, 1904, nos. 15 and 16.

The argument is not that the anatomical principle is faulty because it has failed to accomplish all that had been hoped of it as regards the discovery of the essential nature of disease, but that, under it, certain local aspects of the disease-process are made the exclusive subjects of research, and that the mind is thus turned aside from a recognition of the fact that an equally important object of study is the modification of functional activity, local or general, which marks the efforts of readjustment on the part of the organism to the effects of the primary disturbance. Such a study as this cannot be adequately made without a thorough use of physiological methods, or of clinical methods inspired and guided by physiological conceptions, the term physiological being understood as including all means of research which throw light upon the mechanism of the processes of life. Psychological and chemical investigations belong preëminently in this category. The faintheartedness which most of us have felt in searching for an anatomical explanation of the great neuroses and psychoses has not been simply a quailing at difficulties which were theoretically surmountable, but has been due in part to a justifiable suspicion that we were not altogether on the right track. We have striven to ticket each one of the histories in our case-books with an anatomical designation indicative of some localized pathological process, but we have realized when we did so that our designations usually fell far short of expressing the whole state of the sick man whom we had before us when the history was made.

The widespread feeling that no investigation of symptoms, however thorough, could give us the sort of insight which we needed has led us to underestimate the real value of such inquiries. If the study of symptoms does not carry us to the heart of the disease, neither does the anatomical study of the disease carry us to the heart of the symptoms. In fact, a thorough inventory of symptoms, that is, an inventory of the signs of disordered functions of the body as a whole, can often tell us more of what we wish to know than an inventory of anatomical signs of altered structure. No anatomical research can pierce to the secret of broken coördinations, and yet it is in these that a great part of disease begins, or comes eventually to consist. No anatomical research can help us to estimate the margin of resistance against strain, and yet on the estimation of this margin, for each individual patient, issues depend which are of scientific and practical importance. One man's health is very different in quality and quantity from another man's health, though the two men, untested, may appear alike, and the investigation into their respective powers of effectiveness and of resistance is often a valuable part of the study of their diseases.[1]

[1] Physiologists recognize that organs, such as the heart (*cf.* the address by

We need, in short, to supplement our researches into the direct and local effects of a given lesion by a study into the more or less widespread modifications of energy which the organism exhibits as a result of the lesion, and which it is customary to designate as indicative of an attempt[1] to repair the damages which the lesion has induced. We need also to learn a great deal more about the genesis of symptoms, even though we must remain ignorant about the genesis of what one would call disease, in an anatomic sense.

The signs of readjustment constitute, in fact, all that we can really learn in the study of disease, for the disease-process, considered independently of them, is an abstraction, without real existence.

And if this is so, then all the indications of this process of readjustment are proper objects of our study, whether they be of the nature of symptoms or of anatomic marks, whether they concern special localities and organs which are the seat of primary "lesions," or other parts standing in functional relationship to them, and even though they point to changes which are not to be classed as morbid, but rather as modifications favorable to health. The reactions after a so-called "healthy" fatigue, which often lead to new and better powers of endurance, would be of this latter sort, and the same is true of those reactions through which immunity is secured after infectious disease. At such points as these, "disease" and "health" touch hands, and it becomes, indeed, evident that neither disease nor health is a definite condition, but that both of them are movements toward some relatively endurable equilibrium,[2] a goal which is never fully reached.

Of course, to a certain extent, investigations of this sort are daily made by every student, but the question is: In what direction is it now most important that the emphasis of research should be thrown and scientific instincts developed? Imitation and fashion play a large part, even in scientific investigation, and the almost universal tendency to bend all energies to the search for the physical evidence of localized lesions has led too often to a disregard of disturbances usually classified as functional. Not only is it essential that "clinical medicine" should be studied in the light of "physiology," but the field of morbid psychology, which now lies untilled save by a few students, is one of the utmost practical importance for each practitioner.

Welch, cited below) are able, under special stimulation, to work with more than usual effectiveness. This extra force is called "physiologic reserve."

[1] The word "attempt" and others of like meaning are here used not in a teleologic, but only in a descriptive sense, for it seems plain that we must follow the example of the biologists who have studied the problems of growth and of repair (compare Thomas Hunt Morgan, "Regeneration") and admit that there is no justification for assuming a special *vis medicatrix naturae*.

[2] "Stationary Equilibrium." (Ostwald, *Die Philosophie der Natur.*)

We can hardly treat a patient, no matter with what he may be suffering, without having to reckon on the vast and complex part which his mental attitude will play in controlling the result. In many instances, indeed, the physician's success depends upon the skill with which he makes this estimate. Yet how rarely is it systematically and consciously made, under the guidance of any definite principle, and how gladly would most physicians crowd out of sight the necessity for making it at all. A man meets with an injury attended with great nervous shock, and the neurologist is ready enough to spend infinite pains on the study of the necrotic areas in his spinal cord, but is apt to overlook the fact that this localized process does not explain why he has at the same time lost flesh and strength and color, and has become the football of his delusions and his fears. The data gathered by psychologists and physiologists, and the principles based thereon, count for but little in most assemblages of neurologists. The reason usually given for this disregard of psychological and physiological data is the insufficiency of our means for the verification and interpretation of them. But this fear should not hold us back from making the attempt to utilize these facts, for the same uncertainties attend anatomic research the moment we endeavor to use it for probing the essential problems of disease and life. The confusion attending the recent discussions over the neuron theory and the real seat of neural energy both justify and illustrate this statement.

This attitude toward the problem of disease, which claims pathology as a special department of physiology, is essentially the attitude of Wolkow, to whose stimulating essay I have alluded already, and it is also the attitude of Dr. Hughlings Jackson, of London, whose brilliant studies, stretching back for nearly half a century, mark him as foremost among the advocates of the physiological method in neurological research. Professor Welch,[1] of Johns Hopkins University, has recently made substantially the same claim in his address upon "Adaptation in Pathologic Processes," drawing his illustrations from the department of general pathology. Verworn[2] takes the same position when he speaks of diseases as stimuli (*Reize*), which alter the conditions under which life is carried on, thereby adopting Virchow's designation: *"Die Krankheit ist das Leben unter veränderten Zuständen."*

The physical changes which the organism undergoes in this process of adaptation may be few and slight, and mainly local, or they may be so broad and numerous as wholly to overshadow the lesions by which they were set in motion. In illustration of this overshadowing of the direct effects of a lesion by the processes of

[1] *Transactions* of the Congress of American Physicians and Surgeons, 1897.
[2] *Berl. kl. Woch*, 1901, no. 5, and other papers.

readjustment, I will mention three instances of widely different sorts, yet similar, as I think, in principle. These are: First, myxedema; next, the vast changes that sweep through the organism at the great climacteric epochs of adolescence and the menopause; and finally, those kindred processes of metamorphosis by which through castration the bull is converted into the ox.

In all these cases we see two tendencies at work, the one suggesting disease, or failure, the other pointing toward the establishment of a new sort of equilibrium, containing well-marked elements of stability and health. Is not the controlling principle in these instances analogous to that under which the neuter bee is converted into the queen bee through a change in nourishment, or that through which some of the lower forms of marine animals are altered in type by gradual removal from salt into fresh water, or by some kindred modification of the chemical constituents of the fluids by which they are surrounded?

The conservative physician is usually disinclined to admit biological principles as applicable to the problem of disease. Yet, in fact, it is just in this direction that our search should tend, and when we see complex disorders, such as Graves's disease, or even certain types of neurasthenia, of unknown primary lesion but with hosts of secondary physical and neural signs, we should remember the processes I have cited, and should hesitate before stamping summarily as "disease" modifications of structure and function which doubtless represent, in part, movements toward a new and relatively stable existence. Who can doubt that we ourselves, regarded from another point of view than our own, are defective and mutilated beings, who have sacrificed much to gain the faculties which we justly regard as so important?

This would be a proper place to mention in detail, at least by way of illustration, some of the more important contributions made by physiologists, psychologists, and biologists, which have thrown light upon the clinical problems of compensation and adaptation.

I have already referred to the principle of "physiological reserve" force, as utilized by Welch in his important address, and speak of it here again only as possibly helping to explain the numerous instances where the organism shows the power of fostering certain of the functions of the nervous system at the expense of other manifestations of its life. The case of the runner from the field of Marathon, who brought his message to Athens in spite of the gathering dissolution which laid him dead in the market-place at the moment of his arrival, is a striking illustration of a principle which is of frequent application.

Thus, the disarrangements of the nervous system that are liable to follow nervous shocks of some severity are sometimes very late in making their appearance, and in the interval the patient may appear as if unaffected by the experience through which he has just passed. The final "breaking-down," due to prolonged strain, is often similarly postponed, only to come on eventually with great suddenness.

The fact is often overlooked that there is an analogous "latent period" in the early stages of toxic affections, when the symptoms are masked by this strong tendency on the part of the organism to continue offering an unchanged front in response to the calls of the environment. Thus a patient who is exposed to lead or alcohol may retain the power to use his weakened nerves and muscles for a long period, until finally, under some slight additional strain, complete disability suddenly makes its appearance.

It is apparently this same intense instinct to present a functionally adequate front to the demands of the environment that enables the hysterical patient whose vision is failing to retain the accuracy of the central field, and guides the brain in the reassertion of its powers after injury. The compensation in many cases is so complete as to leave no trace of the primary loss, although some relatively slight additional lesion may make it clearly evident. This is illustrated by the interesting compensatory relationship between the sensory motor functions of the cerebral cortex and those of the semicircular canals discovered a number of years ago by Ewald.

It is as difficult to explain adequately why it is that the organism thus seeks to reassert itself on the old lines, in a physiological sense, as it is to tell why the lower animals are able to make good the loss of important parts and organs, even those of the interior of the body, with regard to which the "habit" of restoration cannot have been acquired through evolution.

Many partial explanations, such as those indicated by Loeb under the name of "tropisms," are indeed of value, but Morgan,[1] after reviewing with great care the evidence at hand for the case of the restoration of the lost parts, declares that a satisfactory explanation is there impossible. One important reason for arriving at this conclusion is that it is by no means invariably true that in the process of restoration the interests of the organism as a whole are consulted. In repair, as in development, the results are often (from the standpoint of the ordinary observer) monstrous or grotesque. And so, too, in human pathology, the processes of compensation and readjustment seem sometimes to work distinctly toward disease instead of health. Nevertheless, these processes must remain the main subject of our study, and the principles underlying them must be re-stated more and more broadly in physiological and philosophical terms, before a unifying conception can be reached.

[1] *Regeneration.*

It is to the clear insight of Hughlings Jackson[1] that we owe some of the most fruitful suggestions as to the mode in which symptoms of disease arise when the normal balance between the various functions of the nervous system has been broken. New light has been thrown on many of the phenomena of which he speaks by the physiologists who have worked on the vast subject of inhibition, and the effects of a disturbance of the interplay between inhibition and excitation. The names of Meltzer,[2] Sherrington, Biedermann, and Wedenski[3] come to mind, especially, in this connection. Nevertheless, the fundamental principles which Hughlings Jackson so long ago expressed retain for the most part their validity. He made it clear that the signs and symptoms met in disease are of dual origin, that portion of them which is due to a lesion such as we might expect to demonstrate anatomically being often the less conspicuous part, while the more conspicuous part is due to the vital energy of the uninjured remainder of the nervous system, acting without due control and yet with reference to such coördination as is still in force. Special and reciprocal coördination of this sort exist between the cerebellum and the cerebrum, so that the special tensions and characteristics of either one is liable to come singly or preëminently into play when the activity of the other suffers a check. The disorders thus set up form "complementary inverses" of each other. Similarly, when any portion of the nervous system is damaged, there are signs of defect, or "negative symptoms," due to impairment of the more highly coördinated functions of the part concerned and related parts, and signs of overaction, or "positive symptoms," due to uncompensated activity of the functions of "lower levels."

These "positive symptoms" might be classified simply as if due to unchecked liberation of energy, or as attempts at compensation (in a duly qualified sense) on the part of the organism as a whole. Sometimes the phenomena which seem at first glance to bear the stamp of "disease" are really better classifiable as of conservative or compensatory nature, while under other circumstances the reverse may also be the truer statement. Thus Strohmeyer[4] has pointed out how "compulsive ideas" may sometimes have a value for the mental health of the patient, and Hughlings Jackson has suggested an explanation for the fact that motor convulsions, in epilepsy, may, at least, be less injurious for the mental con-

[1] The first lecture of "Hughlings Jackson Course," delivered in January, 1898, contains a brief outline of the importance of his generalizations. (*Lancet*, January 8, 1898.)

[2] *Med. Rec.*, June 7, 1902. "The Rôle of Inhibition in the Normal and Some of the Pathological Phenomena of Life, and Other Papers."

[3] Pfluger's *Arch. f. d. ges. Physiol.*, 1900.

[4] "The Conception of Compulsive Ideas as a Safeguard Neurosis" ("Abwehrneurosen"), *Cbl. f. Nervenheilkunde u. Psych.*, vol. XIV, 1903.

dition of the patient than the seemingly less serious psychic seizures.

We owe also to Hughlings Jackson the generalization that lesions which occur suddenly, and throw out of gear, as they are bound to do, the more delicate of the functions represented in that part of the nervous system which is concerned, are likely to be followed by symptoms of a more violent sort than those which take place slowly. Thus, the epileptic discharge accompanying a lesion so slight as to leave no recognizable anatomic trace behind is liable, by virtue of its suddenness, to give rise to a maniacal outbreak, which represents the uncontrolled activity of relatively uninjured portions of the brain, while, on the other hand, lesion which anatomically may appear infinitely more serious are accompanied by no such outburst. Different forms of epileptic discharge and their secondary results differ widely also among themselves in these respects.

These hypotheses are in need of further analysis and should be tested anew by neurologists trained in physiological methods.

Reasoning on lines similar to those laid down by Hughlings Jackson, Edward Cowles has recently sought to unify the various members of the large class of the psychoneuroses of exhaustion, or of lowered mental tension. Thus the different phases of manic-depressive insanity are not due, he thinks, to separate and specific processes for which we might expect to find special chemic or anatomic expressions, one process leading to excitement and another to depression, but these phases, which in fact are often mixed, are phenomena of secondary occurrence, and are explicable on principles analogous to those outlined above as indicating the genesis of epileptic mania.

Some of the principles brought out by Hughlings Jackson are quite in harmony with those insisted upon of late years by a relatively small group of observers, abroad and at home, who have brought psychologic investigations to the aid of clinical research. I have especially in mind the fine work done by such men as Janet and Freud in Europe, Morton Prince and Sidis in America, not to speak of many others who have labored in the same field. To them we owe such knowledge as we now possess of the contrast between the dissociation of consciousness so characteristic of hysteria, and of the contrast between this tendency and that which gives rise to the complex and varied mental phenomena of asthenic states, or to the temporary and quasi-normal disturbances of daily life.

It would be impossible even to name, in a few paragraphs, the many clinical researches tending toward a better understanding of mental symptoms, for the prosecution of which a knowledge of psychological and physiological generalizations is essential. A few illustrations must suffice.

Thus, in every movement leading to exact thought and exact expression, in every movement of the memory, vast numbers of mental processes must coöperate, and if the outcome is to be effective, this coöperation must be governed from the outset by a leading idea as a ruling motive. The failure of this ruling idea leads to the wayward flight of thoughts, so characteristic of various forms of mental weakness, as has been pointed out by Liepmann.[1] The psychological bearing of this principle has repeatedly been insisted on by the keen psychologist, Bergson, both in his work on memory and matter,[2] and in a more recent essay.[3]

The psychological researches into *habit* and *set* are likewise of practical importance. The laws of habit describe the tendencies under which the varied reactions of the nervous system recur under forms which are really stereotyped and predetermined, although simulating the purposive reaction of health, and often only with difficulty to be distinguished from them. The term "set" describes the process by which the reactions of every individual, beside their purposive significance, receive a form and coloring, which, in a measure, reflect the general characteristics of the personal life of the actor, his temperament, his racial traditions, his education. It indicates, as has been justly said, the "signature" in the musical sense, under which the movement of his life goes on. The "set" of each patient must be understood before his illnesses can be mastered. In the study of these important laws psychologists and neurologists can lend each other mutual support.

If a further illustration was needed of the way in which a refined study of physiology and psychology can be made of the highest use to supplement anatomic data, in affording a basis for clinical conclusions, it could be amply furnished by a consideration of the problems of fatigue, that mysterious region, daily traversed, where health and sickness are so strangely mingled.

Thanks to recent investigations, we know a good deal about the anatomy, chemistry,[4] and physiology,[5] of the nervous system in fatigue, as representing the primary lesions, but it needs only a brief reflection to show how numerous and varied are the secondary manifestations, neural and mental, involving eminently the functions of the organism as a whole and in all its parts, that characterize the clinical outcome of acute or of prolonged exhaustion.[6] To

[1] *Ueber Ideenflucht*, publ. by Carl Marhold, Halle, 1904.
[2] *Matière et mémoire.*
[3] *L'effort intellectuel, Rev. Philosophique*, 1902, p. 53.
[4] See especially various papers by Verworn and his pupils, which are published or referred to in the recent volumes of the *Zeitschrift f. Allgem. Physiologie*, 1901 to 1904.
[5] See especially Richet, *Dictionnaire de Physiologie*, article "Fatigue."
[6] See "Neurasthenia," by Cowles, Shattuck Lecture, 1891, *Boston Med. and Surg. Jour.*; see, also, the various accounts of the Exhaustion Psychoses, and of studies on the contests in the Olympian games.

give to these manifestations an adequate expression would often mean the passing in survey the functions of all the organs of the body. This is a task which would be anatomically impossible, since even the most extensive anatomical survey would fail to take cognizance of the disarrangements of old coördinations and the establishment of new ones.

Almost equally important with the generalization that the manifestations of disease are largely compensatory or adaptive, *i. e.*, vital or physiological manifestations on the part of the organism, is that which describes these changes as affecting *not organs, but functions.* This view is justly made much of by Wolkow, who points out that too close an adherence to the analytic methods of the anatomist encourages a tendency to regard the body as a congeries of organs, of tissues, and of cells, having an independence of each other which, in reality, they do not possess. A mode of conception such as this robs the organism, regarded as a whole, of its individuality, and as a substitute for it we need to cultivate the habit of regarding each individual as representing a vast system of interlocking functions, partly known to us already, partly unknown. It is during the disturbances and reorganizations of these functions, either in themselves or in their relations to each other, that the symptoms of disease arise, and the problem of the physician is to cast up the patient's account at each critical juncture, and to reckon upon what assets, in a physiological sense, he has yet to reckon, upon what powers of compensation and readjustment he can still rely. In place of regarding the body so much by piecemeal, we need to regard it more as a whole; as a supplement to our study of structure we need a closer study of function. Some diseases, as Wolkow suggests, could best be defined as disorders of unknown functions. It is probable that, under the same principle, those disorders which we now classify as due to premature death of anatomical parts[1] could be more properly described as due to the premature falling-out of more or less specialized functions.

In no department of pathology is it so difficult to arrive at satisfactory conclusions by the aid of the anatomic method alone as in the department of neural pathology. For it is the nervous system upon which the organism preëminently depends for the very existence and efficiency of these interlocking functions which are the basis of life. We can get on without admitting the existence of matter, in the familiar sense of that word, but we cannot get on without admitting the existence of *energies*,[2] superposed one over

[1] Termed by Gowers "abiotrophy."

[2] Of course, in the final analysis, it must be admitted that any given conception of "energies" can be taken only in a symbolic sense. It is, however, at present, the term most conducive to clear thought and adequate generalization.

another in ever increasing complexity of organization, and to admit this conception of energies is at once to throw the emphasis of research upon the study of functions, and to admit the significance of the anatomical method only as a valued help toward the better understanding of function.

One unfortunate result of a too close adherence to the anatomical method is that it has introduced into medical literature, and, more important still, into medical thought, a differentiation of disease into two contrasted, although vaguely defined, categories designated as "functional" and "organic," two terms which are objectionable because they help to perpetuate false notions of physiologic, pathologic, and clinical sorts.[1]

However useful these terms may have seemed as affording a convenient, if rough, classification of diseases, and however inspiring it is to reflect that with the idea of "functional" goes that of possible curability, it is nevertheless true that their employment has had a mischievous because misleading effect, and that it turns away the mind from the true recognition of a nature of the facts at stake.

Contrast, for example, the cases of hysteria and epilepsy, with regard to which these terms are often used, as if with an essential meaning. If in calling hysteria "functional" and epilepsy "organic" it is meant that the one is curable and the other incurable, neither assumption is strictly accurate. If it is meant that in the case of hysteria there is, presumably, no essential anatomic peculiarity of the brain and nervous system, while in epilepsy such a peculiarity is present, neither assumption is correct. For no one can doubt that the brain of the hysteric is in some degree abnormal, and while we must make the same assumption in the case of epilepsy, we know nothing of the actual change which brings the epileptic fit about or makes it possible, nor can we even say that the fit itself is not a conservative process, in a certain sense. Again, the epileptic paroxysm, as such, is a sign which distinctly deserves the name of "functional," as much when occurring spontaneously as when induced by experimental excitation of the cortex. Furthermore, it would be only partially correct, and certainly not scientific, to call hysteria a "functional" and epilepsy an "organic" disease because epilepsy occurs oftener than hysteria in patients who exhibit certain physical peculiarities which we classify as stigmas of degeneration.

It would be equally erroneous to claim that having classified a disorder as "hysterical," and therefore as "functional," we have the

[1] Compare in this connection Obersteiner, *Functionelle und Organische Erkrankungen*, 1900; and Krehl, *Die Functionelle Erkrankungen*, in *Die Therapie der Gegenwart*, 1902.

right to consider it as representing a condition which anatomy need not take into account. Mental action is, in every sense, a real force, standing on the same plane with the other forces which we regard as more familiar, and as such it is capable of influencing the nutrition of the body. It is only by evasions and subterfuges that we can deny the reciprocal relationship between bodily processes and mental states. Both of them are manifestations of energy, and there must be some denominator common to them both. Between death from a bullet that traverses the brain and death from an emotional shock, the difference is one solely of detail. When any disorder such as we should be inclined to call functional is hostile to the fundamental interests of the organism, it leads at once to manifest disorders of the nutrition. Not only is this true of depressive emotions, but even of excessive intellectual preoccupations, as when Dante said, "My great work has made me lean." This datum of common observation is receiving, more and more, the solid indorsement of scientific thought. Thus, Ostwald [1] dwells upon the fact that mental operations of a pleasurable sort directly favor nutrition and the normal flow of chemical energy, while those of a painful sort interfere with nutrition and hinder the flow of chemical energy.

At both these latter points the barrier between the functional and the organic is broken down. As a matter of fact, this barrier does not by right exist, and we should not be tempted to use the terms "functional" and "organic" as applied to disease at all were it not for two reasons, the first being the convenience of the custom, the second that there are many conditions which we recognize as being on the whole hostile to most of the interest of the organism and which we therefore feel justified in classifying as disease, yet where the disorder is not adapted for anatomical expression. If we adopted, as we should, the conception defended by the clear-minded philosopher and scientist (Ostwald), that the organism is a fabric built up, not of atoms, but of energies, we should never draw these unscientific distinctions between "function" and "structure," or "symptomatology" and "anatomical expression," as standing for fundamentally different and contradictory conceptions, or as affording the one a truer and the other a less true method of approaching the study of disease, but we should admit that the data gathered under these different headings stand upon the same plane as regards their admissibility as evidence. The data furnished by the study of symptoms, which in the case of the so-called functional disorders constitute all the evidence at our command, are data of a physiologic sort, and throw light rather on the reactions of the organisms than on the direct effects of the primary lesion. For this reason they are not susceptible to discovery by anatomic means.

[1] *Philosophie der Natur.*

In conclusion, then, I offer the following propositions:

Every organism, whether we call it diseased or well, presents itself to our view as a web of interwoven "energies," which, in order to study them by anatomic means, we must break artificially into fragments that have, in reality, no correspondingly separate existence.

These energies, under tendencies which countless ages of evolution have established, have woven themselves into a mechanism of interlocking functions, forming an endurable and relatively stable equilibrium, which we denominate as health. This equilibrium, however, must always remain but relative, and would become a real equilibrium if that were possible only at the sacrifice of further evolution and progress.

The processes of mutual modification and adjustment through which such an organism seeks to gain and to maintain this equilibrium, under the ordinary conditions which we classify as health, are the only means which it possesses to meet the more serious needs created by the unusual conditions that we call disease.

It rarely happens that these efforts [1] at readjustment (after any considerable disturbance of this equilibrium) are thoroughly successful, and in the abortive or exaggerated reactions on the part of the organisms, energies are set free and habits are established which are often hostile to the main interests of the organism as a whole, and therefore are reckoned as evidences of disease.

In many cases the processes of readjustment are taken part in by various functions of the organism which do not seem to be at first sight related to the changes primarily at stake, to such an extent that the earlier effects of the original lesion are overshadowed, and we seem to be in the presence of what would be called a change of type rather than a disease. In this way, for example, what are called by biologists the "secondary sexual characters" arise. Clinical examples of this tendency toward such a generalization of the process of readjustment have already been suggested.

Although these processes of readjustment do not seem to be guided by teleologic influences, and although they often fail to benefit the organism, and, instead, work it great mischief, yet in many instances they do have all the outward appearance of being under the direction of some general principle analogous to that which governs the processes of growth, and is manifested in the repair of lost parts among the simpler forms of life.

The tendency, according to which the processes of repair are governed by a "general principle," presents interesting analogies with the government of the flow of thought and memory by a "lead-

[1] It is to be understood, as stated above, that the term "efforts" is here used in a descriptive sense alone.

ing idea." The same tendency probably finds application in fact, in the case of all complex reflexes, no matter of what sort.

In order to give aid and guidance to the more favorable elements of these processes of readjustment, we, as physicians, need to bend all our powers to a better understanding of the resources which each organism has at its command for compensation, for continued life on the old lines, or for gaining a new and more stable life, no matter at what sacrifice. The patient who thoroughly understands his resources and is master of them, even if these are few and slight, is often in a better position than one who has more to draw upon but who is liable to be upset by surprises.

In the accomplishment of this task we need all the help that anatomy can furnish, but as it is the organism in activity that we seek eventually to understand, it is necessary that the splendid services of anatomy should be supplemented by physiology, and the physician — above all the neurologist — needs, therefore, to be trained, more thoroughly than at present, to work and reason in accordance with physiological conceptions and methods as applied to the problem of disease.

As regards our duty in the treatment of our patients, we should not fail, first of all, to seek for the original cause, wherever it may lie by which the old equilibrium of relative health has been, in one direction or another, broken into, and we are, therefore, bound to acquaint ourselves with all those functions and processes which are related to nutrition in the broadest sense. Still, for the neurologist in particular, the problem of nearest interest is often to gain a point of temporary vantage for his patient by training him to make the best of a present situation, and the methods by which this end is to be accomplished are classifiable under the general name of education.

In these methods the future therapeutics of the nervous system is largely to assist; to them we are more and more to look for guidance, both in relieving our patients of their ills and in teaching them how to bear them. The physician who knows best how to appreciate the needs and resources of those coming under his care, to divine their capabilities, to search out the hidden causes of their present troubles — lying, perhaps, in the experiences of childhood — the physician who has the trained keenness to recognize that, however poor the material with which he has to work, there is almost invariably some benefit to be gained, if not in the direction of relief, then in that of compensation — such a physician as this can make himself of infinite service to the community in which he lives and works.

As among the newer representatives of the successful laborers in this field, we ought to recognize not the scientific investigators alone, but also those practical workers, whether lay or medical, who have shown what education can actually accomplish. I have in mind, especially, the physicians who have demonstrated that tabetic ataxia can be relieved, the sufferers from obsessions and morbid fears restored to their place in society, the vacant lives of imbeciles and dements made more full, and new promise given to the efforts for the reform of the waifs and wards of our great cities. In this outcome is to be sought one of the best practical pieces of evidence for the value of the physiological principle in the problem of disease.

SHORT PAPER

Dr. C. L. Herrick, of Granville, Ohio, contributed a paper, read by his brother, Dr. C. Judson Herrick, on "A Comparative Method in Psychology, particularly in its physiological and anatomical relations."

SECTION G—PSYCHIATRY

SECTION G—PSYCHIATRY

(*Hall* 7, *September* 22, 10 *a. m.*)

CHAIRMAN: DR. WILLIAM A. WHITE, Government Hospital for Insane, Washington, D. C.
SPEAKERS: DR. CHARLES L. DANA, Cornell Medical School, New York.
DR. EDWARD COWLES, Boston.
SECRETARY: DR. C. G. CHADDOCK, St. Louis, Mo.

PSYCHIATRY IN ITS RELATION TO OTHER SCIENCES

BY CHARLES LOOMIS DANA

[**Charles Loomis Dana,** Professor of Nervous and *ad interim* Mental Diseases, Cornell University Medical College, New York; Visiting Physician, Bellevue Hospital; Neurologist to the Montefiore Hospital. **b.** Woodstock, Vermont, March 25, 1852. A.B. Dartmouth, 1872; A.M. *ibid.* 1875; M.D. College of Physicians and Surgeons, Columbia University, New York; LL.D. Dartmouth, 1905; Professor of Comparative Physiology, Columbia School of Comparative Medicine, 1879–82; Professor of Physiology, Woman's Medical College of New York Infirmary, 1882–90; Professor of Nervous Mental Diseases, Post-graduate Medical School, 1886–96; Professor of Nervous Diseases, Dartmouth College, 1892–95; *ibid.* Cornell University Medical College, 1896. Member (ex-President) of the New York Neurological Society; American Neurological Association; Charaka Club; President, New York Academy of Medicine; American Association for Advancement of Science. **Author of** numerous articles and monographs on nervous and mental diseases.]

THE task of preparing an address upon the relations of psychiatry to other sciences presents some embarrassments. Psychiatry itself, in its narrower sense, is the science that deals with the phenomena of disordered minds. But the psychiatrist has also an applied science to utilize, or in reality a business to perform, which engages much of his energy, and is a very dominant thing in his professional life. This business is that of the administration and care of the insane, and it is hard to ignore its immense importance in discussing psychiatry from any broad standpoint.[1] Indeed, one may say that the most real advance in the treatment of insanity lies in the improved methods of hospital care that have been developed in the last thirty years. Still, the science of psychiatry, as pursued by the clinician and the pathologist, is that phase of it which must, for our present purposes, be set apart and its "problems" and "relations" studied.

[1] Among 5470 contributions to psychiatry made during the five years, 1894–1899 (Jahresberichte für Psychiatrie u. Neurologie), the number devoted to different groups of subjects was as follows: General symptoms, pathology and etiology, 1749; special psychopathology and therapy, 1581; administrative methods and reports, 1286; forensic medicine, 854. Thus writings concerning administrative care make up over 20 per cent of the total literature of psychiatry.

I do not know how one can very well entirely separate these topics from each other, and I must be excused if I sometimes slip from speaking of a relation to dealing with a problem. After all, the thing desired in such an address as this is, I assume, to find out how psychiatry stands as a science now, what dependence it has on other sciences, and what help it needs from them or can give to them.

Twenty years ago I was a member of an organization for securing reforms in the care of the insane. It fell to me to present the situation then of psychiatry in America. It may be said that at that time little science of this kind existed here. This was so much the case that the superintendents of the insane asylums had withdrawn from affiliation with the American Medical Association, and had for years kept out of formal touch with general medicine and the activities of medical science. Psychiatry had mainly one side: the business of administration and custodial care. Only four medical schools pretended to give any teaching in mental disease in the whole country. There were then only 74 state asylums, with a population of 39,145 insane and considerably less than half of the insane of the country were in institutions designed for their care. The cost of running these institutions was about $200 per capita yearly, which is perhaps a fifth greater than it is now. So that psychiatry represented a business conducted in some places well, in some ill, as sentiment demanded or as money was supplied.

This situation was a natural one considering the state of public feeling and of medical science at that time; for the thing to do with the alienated, when only one thing can be done, is to take good care of them; after this we can study them and build up a science and an art. And this is what has happened.

During the last twenty years there has been steadily developing a science which deals with mental disease. Largely through the influence of certain clear-sighted administrators of our hospitals, our knowledge has developed until now we are justified in classifying psychiatry among the medical sciences, surpassing in exactness some, and in importance, interest, and difficulty perhaps all, of the other branches of medicine. For we are dealing in its study with the ultimate and finest and most elaborately differentiated product of organic life, and our task with it is not only to study and to classify, but to prevent and to save that which is most essential to human progress — the human mind.

During these past twenty years the administrative care of the insane has also steadily improved, so that now in our best semi-private and endowed institutions there is really little more that humanity could suggest or ingenuity devise for the comfort and care of the patient. In many of our state institutions there has been also a steady progress, which is hampered in some states by poverty and lack of intelligent interest, and in nearly all by the allied science of politics. Indeed, while this last exists, state hospitals will always fall a little short of the ideal. The psychiatrist stands on one hand striving to bring things up to his highest views, the politician on the other, urging something cheaper, and standing for an influence that tends toward mere custodianship.

The science of psychiatry comes in touch with many branches of human knowledge. In so far as psychiatry has a practical side, it stands in close relation with what may be called, in general, *economics;* to an extent, also, it is in relation with all those sciences which particularly tend to prevent and ward off insanity by improving social conditions through sanitation, education, and better heredity.

The science of psychiatry utilizes, at all times, the work of the psychologist, but, most of all perhaps, it stands in relation with certain departments of internal medicine, such as pathology, and chemistry. Psychiatry has also certain relations with the law, with the criminal, and in general with abnormal man.

To take up all these relations in detail would make an address very long and very desultory. Yet I do not see how, in the nature of the case, my remarks will not have some of both these characters. I shall, however, while touching on a number of topics, lay special emphasis on a few that seem most important.

Psychiatry and Economics

The relation of psychiatry to economics is one of increasing interest and importance. The loss to the state and the expense in money from disease is a subject that has received increasing attention of late years, until now in many directions public knowledge and state action are almost adequate to the problems involved. The results have been the extermination of some and the holding in check of other diseases. Thus, in the more advanced communities, with the exception of certain pulmonary troubles, and a few of the infectious and eruptive fevers, the prevalence of microbic diseases has been decidedly checked.

Nervous diseases, however, if we include also those due primarily to vascular disease, are probably more numerous than ever. Statistics are almost useless for determining this question, because there is no common nomenclature, the diseases are not notifiable, and, at best, we must go by death statistics. I believe it to be common medical opinion, however, as it is certainly my own, that both organic and functional neuroses are relatively more numerous than they were fifty years ago.

As to the psychoses, there is little doubt that they are also increasing, relatively, more than the population. This is shown in the reports of those states in which statistics have been more carefully kept, as, for example, in Massachusetts, New Hampshire, and New York, as well as by the census statistics of this country and Great Britain. We may say that in the last twenty-five years the ratio of sane to insane has shown an apparent gradual increase from 1 to 450 to 1 to 300, and this latter seems to be about the ratio in those communities of North America and Europe in which modern conditions of civilization prevail.[1] This average has varied but little in the last few years; the slight yearly increase probably will not change rapidly and probably not continue. For when the increase in the insane reaches a certain point of excess, society will have to take notice of it and correct it.

For twenty-five years the explanation for this increase has been that more cases were observed and more victims kept in institutions than formerly; and this is still the explanation. It is my opinion, however, that the increase is a real one, and it is one to be expected, not only from the strenuousness of modern life and increase of city population, but also because more feeble children are nursed to maturity and more invalid adolescents are kept alive to propagate weakly constitutions or to fall victims themselves to alienation; the period of life susceptible to insanity is longer.[2] A fourth of the cases of insanity are due to so-called moral causes: emotional strain, shocks, and vicious indulgences. But moral causes are not sufficient to cause insanity if the individual has a sound constitution. Insanity is increasing in part, then, because we are saving too many lives by the careful regulations of our health boards. Hence, those who are working so enthusiastically, and nobly, and successfully in preventing disease achieve results which carry serious responsibilities for the state.

[1] The somewhat startling increase in suicide is corroborative of an increase in psychopathic constitutions.

[2] The expectation of life is now 43.59 (Newsholme). The death-rate of children under 5 has dropped from 68.6 to 64.5 in the years from 1865 to 1895 in Massachusetts. The drop in the death-rate, from 5 to 40, has been much greater, while the death-rate above 40 has increased. (S. W. Abbott, Vital Statistics, Wood's Ref. Handbook, vol. VIII.) The period of life during which insanity most frequently occurs is 30 to 40, and next, that between 20 and 30. The average age at death in England was:

	Males.	Females.
1840	27.15	29.38
1900	33.63	39.90

	Excluding 0 to 4.		Excluding 0 to 54	
	Males.	Females.	Males.	Females.
1840	46.46	46.77	72.09	73.05
1900	53.17	55.21	70.41	71.92

—S. G. Warner.

Expectancy of life in Massachusetts:

1880	44.64
1900	46.05

— U. S. Census Bulletin, No. 15.

The average age at death has increased from about 28 in 1840 to 34.5 in 1900, thus bringing more people into the third decade, which is the one most fruitful in insanity.

Let us see what the facts are regarding the economic loss of insanity :

There are in the United States now about 145,000 insane; 120,000 feeble-minded; a ratio of about 1 to 300.

The annual increment of insane in Massachusetts, according to the Massachusetts Board of Lunacy, is 400 in about 10,000, or 4 %.

At this ratio, the annual increment for the United States would be approximately, 5600.

The cost of maintaining properly these 145,000 can be estimated fairly on the basis of the cost of the institutions of the two large states (Massachusetts and New York), where it is admitted the work is at its highest efficiency.

The plant for caring for the 22,000 insane of New York is valued at $22,000,000 (Mabon), and the plants for caring for our insane, if we are desirous to care for them in the way creditable to a great civilized and wealthy nation, should be not less than $150,000,000. To run this national plant the cost is, at a moderate estimate, $3.50 weekly, per patient. This is about the average in New York and Massachusetts and most properly organized state hospitals elsewhere. This gives the insane no luxuries either; for the average cost of properly caring for the insane in private institutions is $12 to $25 per week. This with the interest on the plant makes the actual objective cost of caring for the insane of the United States every year about $40,000,000.

This does not include the care of the feeble-minded. So far as the state is concerned they are less of an expense because a large number are cared for in families. Many do not need actual responsible supervision, and many can in a degree support themselves. Finally, the feeble-minded are short-lived, while the insane live into and beyond middle life. At the best, however, the idiot or feeble-minded are persons whose lives are a burden and a sorrow beyond what is measurable in money. An idiot cannot be supported for much less than the insane, and it is safe to put down $20,000,000, yearly, as the sum we pay for having the idiot with us. But $60,000,000 a year does not represent all; 70,000 of the insane are men and presumably breadwinners. The average worth to a community of a healthy worker is about $400 a year. This sum is subtracted from industrial activity by his sickness. Assuming that the 70,000 insane men could earn this sum, we have a loss of $28,000,000 more per year. It seems to me that it would not be far out of the way to say that the care and cost of the diseased and defective brains of the country is over $85,000,000 annually, and is increasing absolutely at the rate of 4 %. These figures, perhaps, are not so very alarming to a nation with an income of $600,000,000. It is a sum that would not quite run the city of New York, or support an army or navy. But it is an item to be reckoned with by economists; and the side which cannot be represented by figures is still more important, viz., the sorrow and suffering and indirect loss in health and happiness.

If there were a science of state medicine, the economic study of insanity which brings out some such figures as those I have just presented would be called into demand.

State medicine in some of its branches is supposed to give us means of relief from social evils due to disease. In the case of insanity it would have to call upon various minor divisions of science for help. The study, for example, of the causes of insanity, teaches us that if we could subtract alcoholism from our social life, and nothing took its place, we should cut out about a tenth of the cases of insanity brought on directly by this poison. We should probably subtract a large number, brought on directly through alcoholic parents. If we could subtract syphilis from our civilization, we could cut out a tenth more of the insane. If we could do away with violent passions, shocks, mental strains of various kinds, we could cut out perhaps 25 % more of the insane.

But after all, supposing even these practically impossible feats could be accomplished, there would still be left a large percentage of the alienated, and this percentage would include persons who developed disordered minds because they were born with a tendency to mental degeneration.

It follows that the most immeasurably important factor in attempting to limit and prevent insanity is to secure well-born children; to see that those people who have weakly constitutions, or poisoned constitutions, do not propagate the kind. This is, of course, a thing which can only be accomplished by long years of careful education and training. The science of *eugenics* is hardly yet existent, and if it were a full-fledged science, the people are not educated to receive its teachings. There are, however, known to be certain fundamental principles of "eugenics" which cannot be too strongly insisted upon. One of these is that persons who have strongly alcoholic tendencies, or who are dipsomaniacs or drug-takers, are almost sure of breeding degenerate children. And the same is true of those who are plainly syphilitic, or who are on both sides tuberculous, or on both sides psychopathic or neuropathic. One further point only I wish to make in connection with this subject, and that is the question of the results of the amalgamation of races in this country. While the ratio of insanity in the United States is fully up to that of other civilized nations, it is not especially in excess, hence it cannot be said that the fusing of different races here has yet caused deterioration. Nevertheless, it is a practical and serious question as to what will be the eventual result. We know that when widely different races, like the African and Aryan, mix, they do not breed good men and women.

We know that, on the other hand, races such as the Jewish and the Japanese, which have kept themselves pure for centuries, have reached a very high stage of efficiency. So far as history shows, we have no clear proof that the mixing of races breeds races of a higher efficiency. But we do know very well that the mingling of very widely different races leads to a degenerate quality of hybrid. What will be the result of fusing together the typical Anglo-Saxon with the dark-haired Latin, Slavic, and Semitic races of Southern Europe, remains to be seen. Since they are all of Indo-Aryan stock, no harm may result, but I have personally observed most disastrous results among children of unions between the Scandinavian and the Spanish races.[1]

Psychiatry and Psychology

The science of psychology stands nearest to psychiatry of all the non-medical sciences. It should, in fact, bear the same relation to clinical psychiatry that physiology does to medicine. It furnishes us the normal standard of mental activity, and should give name and definite description of what takes place in the healthy mind. Therefore, it is as important that the psychiatrist should have a sound knowledge of the elements of psychology as that the neurologist should know the anatomy of the nervous system.

For after all psychiatry is now and will long be essentially a clinical science, a study of a grouping of symptoms. In neurology we make three diagnoses when the art is perfectly exhibited. We have a clinical diagnosis by which we recognize a symptom group, a local diagnosis by which we recognize the seat of the disease, and a pathologic diagnosis by which we recognize the nature of the trouble. In psychiatry only the clinical diagnosis is made as a rule, and this clinical diagnosis is really dependent mainly on the study of the psychology of the patient. Clinical psychiatry is, in fact, only morbid psychology.

All this would lead us to think that the relation of psychiatry and psychology should be an intimate one. As a matter of fact, psychologists do not write with much reference to the morbid mind. This at least is my experience in an effort to orient myself on this subject.

[1] In a study of the subject of immigration and nervous and mental diseases, made in 1882 (*Annual Report* of American Social Science Association), I reached the conclusion that immigration tends slightly to increase the amount of insanity out of proportion to the native population, partly through influence on social life and partly through the introduction of poor stock.

Only a portion of the immigrants and certain special races have these tendencies. Immigrants were found to develop an excess of organic disease, but to have fewer functional nervous diseases than natives, due probably to their social conditions and the exposure incident to poor methods of living.

Twenty years ago the foreign-born made up a fifth of our population, and contributed to a third of the cases of insanity.

We as alienists do not need a large vocabulary or very recondite knowledge of psychology. We do not require to hold opinions on association theories, or on parallelism or monism, or epistemology.

We do very much need definite descriptions and harmonious views of the elementary mental processes.

We deal in disorders of sensation and perception, in failures of memory, perversion of judgment, states of feeling either too intense or depressed, loss of the volitional function, and disorders of instinctive reactions, of memory and of consciousness. Yet it is not easy to find these states clearly defined among psychologic authorities. I have a list of the psychologic terms used to describe groups or individual symptoms in psychiatry. This vocabulary of involved symptoms has only about twenty-five terms, but they mean different things according as the physician takes his psychology.

Psychiatry is having its great difficulty in classifying its cases. Practically every writing alienist has a special classification of his own. This is in part because cases cannot be observed completely or recorded thoroughly without a proper language for recording the facts. The older alienists never knew the science of psychology, because there was none; the modern are only learning it. A thorough and especially a uniform understanding of psychology is necessary in order to give sharper definition to observed phenomena, to bring out new facts and to clarify the symptomatology and make us agree upon our groupings. For example melancholia used to be considered as essentially a morbid depression of the mind. Now we know there are other elements such as retardation and difficulty of thought and action, of disturbance of attention and volition; we find, in fact, that there may even be a melancholia without any melancholy. It is in the observation of the often obvious psychic states and in the correct record of all deviations that we may expect to make real progress. And we need a uniform psychologic vocabulary for our purpose, as well as a pretty thorough psychologic training.

I have collected from the writings of Stout, Morgan, James, Baldwin, Ladd, Calkins, Titchener, Sully, the definitions or views given by them of the elementary and other mental processes:

Sensation, impression, perception, percept, conception, concept, image, idea, ideation, judgment, reason, reasoning, emotion, feeling, sentiment, conation, will, volition, consciousness, memory, association. There is substantial agreement about the significance of perhaps the majority of them, and I quite understand that the mind is not to be divided into sharply limited mental processes, but that mental states are all complex and that one process overlaps another.

Nevertheless, there are decided differences and vaguenesses in the views of sensation, perception, of concept, memory, image, idea, will, consciousness. The establishment of a better relation between psychiatry and psychology is at any rate a thing much needed, but belongs, perhaps, to the problems of psychiatry.

The following are examples of the differences in the definition of elementary psychological terms among leading psychologists.

Impression is the simple result of a stimulus. (Morgan.)

Sensation is the discrimination and recognition of the impressions as of such and such a quality. It is the reception and discrimination of impressions which result from certain modes of stimuli, like sight, hearing. (Morgan.)

Perception is the process by which sensations are given objective significance, being supplemented by revived sensations. (Sully, Morgan.)

Perception always involves sensation. (James.)

Percept is the aggregate of the revived and actual sensations, integrated and solidified. (Morgan.)

Perception (Wahrnehmung, Anschauung):

(1) Cognition, so far as it involves the presence of actual sensation as distinguished from mental imagery.

(2) Cognition of subjective process as such; the apprehension of the actual presence of this process in distinction from the ideal representation of it. (Stout, Baldwin.)

The old writers used perception as a synonym for cognition in general. The later tend to fuse sensation and perception. Some speak of inner sense, inspection or introspection as perception.

Perception (Wahrnĕhmung) is the process of the apprehension of sense-objects.

Anschauung is rather sense-intuition. (Baldwin, *Dictionary of Psychology*.)

Memories of percepts are simple, particular or concrete ideas. (Romanes.)

Image (Bild). The mental scheme in which sensations or the sensory elements of perception are revived. (Baldwin, Stout.)

Idea (Vorstellung). The reproduction with a more or less adequate image of an object not actually present to the senses. (Stout, Baldwin.)

A mental image is an idea, according to Ladd.

The German *Vorstellung* is sometimes used to cover both perception and idea, and there is a tendency to give the same wide application in English. (Titchener, *Outlines of Psychology*.)

In a perception the object perceived is usually supposed to be present.

Ideas which are general and abstract are concepts. (Romanes.)

Ideas which are complex, compound, or mixed are recepts. (Romanes.)

Ideation is the elementary mental process involved in all work of the representative faculty. The products of this are mental images or ideas. (Ladd.)

Conception is the function by which we identify a numerically distinct and permanent subject of discourse. (James.)

Concepts are the thoughts which are the vehicles of conception. (James.)

A *concept* is a general notion or general idea. (Sully, Romanes.)

A *concept* is an image or general idea into which there have entered elements which have been isolated by analysis. The term *soldier* may stand for a percept or concept according as there are associated with it qualities not identified with a particular *soldier*. (Morgan.)

A *concept* (*Begriffbildung*) is cognition of a universal as distinguished from the particulars which it unifies. The universal apprehended in this way is called a *concept*. It unifies a distinction between the universal and the particular.

In philosophy it is common to apply the word more widely, so as to cover the universal element in knowledge, *e. g.*, the categories of Kant were called *concepts*.

In psychology, John Roe is a particular concept; a triangle is a general concept. (Stout, Baldwin.)

Reason, in English, means often reasoning or reflective thought, less often intuitive and certain knowledge. (*Dict. of Psychology.*)

Reason is a form of knowledge which apprehends in one immediate act the whole system, both premise and inference, and thus has complete and unconditioned validity.

This distinguishes it from understanding (*Verstand*), which is a form of knowledge that is discursive, and hence based on premises and hypotheses not themselves the basis of reflection. (J. D., *Dict. of Psychology.*)

Reason (*Verstand*, *λόγος*) is that faculty or process of mind which consists in the drawing of inferences. (G. E. M., *B. Dict. of Psychology.*)

There are other more restricted definitions given:

Reason is to pass from certain judgments to a new one. (Sully.)

Reason includes the formation of a judgment or concept, not inference, then passing from it to a new one. (Morgan.)

Judgment (*Urtheilskraft*, *Urtheil*). The mental function and act of assertion and predication. The term is also applied to the resulting assertion as well as to the process or function. Judgment as a mental process is similar to belief. (Baldwin.)

Modern psychologists find it difficult to define belief and judgment without overlapping, and French psychologists class delusions or false beliefs as disorders of judgment.

Judgment is a conscious mental synthesis, a unifying act. (Ladd.)

Judgment is an inference in the form of a proposition. (Morgan.)

Conation (*Streben*). The theoretic active element of consciousness, showing itself in tendencies, impulses, desires, and acts of volition. "Conation" in general "is unrest." The term will (*wille*) is often used in the same sense.

Streben is translated *effort* by Titchener.

Begehren is used for *conation* by others. (*Dict. of Psychology.*)

Volition is the faculty of the forked way, the possibility of action or inhibition. Man has perceptual volition, in which he is conscious of a choice, but does not reflect upon it. He has conceptual volition, in which he is conscious of choice, and can reflect upon his choice. (Morgan.)

Volition is a definite conative activity consciously directed toward the realization of some mentally represented end, preceded or accompanied by a desire, and usually accompanied or followed by the feeling of effort. (Baldwin, Stout.)

The settlement by the self of a psychic issue, the adoption of an end. (Baldwin, Stout.)

Will is that conative organization of which volition is the terminus or end-state. Will is conation in the concrete, determined in an actual terminus by volition. (Baldwin, Stout.)

Emotion (*Affect*). A total state of consciousness considered as involving a distinctive feeling-tone, and a characteristic trend of activity aroused by a certain situation which is either perceived or ideally represented. (Stout, Baldwin.)

Feeling or feeling-tone (*Gefühl*) is absolute emotion.

The same conscious state may be regarded either simply as feeling, emotion, passion, or sentiment. (Ladd.)

Consciousness (*Bewusstein*). The distinctive character of whatever may be called mental life. It is the point of division between mind and not mind. (Baldwin.) Whatever we are when we are not unconscious, that is consciousness. (Ladd.)

Earlier psychologists called it the mind's direct cognizance of its own states and processes.

The word is not even indexed in Calkin's *Elements of Psychology* and is not defined by James.

Consciousness or *awareness* means, according to G. Spiller, that a notion does not stand by itself, but is connected to another notion; the word "connection" may better be used for it.

Psychiatry and Physics

The science of physics is in closer relation to the administrative care of the insane than to psychiatry proper. Light and electricity have as yet little to do with our pathology, and not much with our therapeutics. We are watching, however, with interest, the various newly-discovered light-rays and their influence on bodily function, as well as the new conceptions of the elements, and their possible bearing on the physiology of the mind.

So far the medical and surgical effects have been superficial and have produced results only on gross and objective evidences of disease, such as tumors, ulcerations, etc. Some claims have been made that the Röntgen ray will relieve pain in neuralgia and tabes, will lessen or check convulsive attacks in epilepsy, and have a real physical effect upon the lymphatic and glandular tissues, as in thyroidism. It is not impossible that some forms of radiant energy passed through the nervous centres may modify the metabolism and produce therapeutic results, but this is speculative, and it is not likely that, at the best, much can be accomplished.

It seems to be well established that very rapidly alternating electric currents of enormous voltage, when passed through the body, increase metabolic changes, but here again nothing very definite has yet been achieved therapeutically.

The problem of helping the alienated by physical means is a serious one — it means that we must change a psychopathic constitution so that a person who has a melancholia or is threatened with it will be rid of the disorder and of the tendency to its recurrence. Some readjustment of glandular activity of the liver or stomach, or some increased activity of absorption and secretion and elimination, must be secured, or by some subtle influence we must teach the brain-cells to build up and break down in a normal and well-balanced manner, or by specially directed training structural defects in the arrangement or insulation of the neuron must be overcome.

Here is a field in which the finer physical forces may play a part, and we already know that the influence of direct sunlight is helpful in delaying degeneration. Other physical agencies may be found which will furnish more.

I can only suggest the possibility that in psychic activity there may be radioactive changes, a breaking-up not only of molecules which we know occurs, but of the atoms themselves. This hypothesis is in the line of the alleged *n*-ray phenomena of Blondlot.

Psychiatry and Psychotherapy

It is a popular question whether the mind does not produce more diseases than do organic changes of the body. In fact, the supporters of the belief that the mind is more important than the microbe make a large cult in this country.

I do not know that the question really deserves very serious consideration. A little acquaintance with dispensary and hospital practice and the records of the health boards is sufficient to show that mental states rank far below the infections, poisons, inflammations, or injuries as makers of symptoms among all classes. I think it would be safe to say that the general practitioner meets a real objective disease twenty times to one in which the symptoms are due to the attitude of the mind. The mind disturbs functions and creates symptoms, but it muddles rather than makes disease. To be sure, it is indirectly a potent thing. Thus, in conditions of profound depression there is a lessened vital and circulatory resistance, and infection can creep in. It would never do for physicians to fight an epidemic with cold hands. Conditions of the mind can favor or delay digestion and peristalis, and there is, indeed, no function more susceptible to physical control than the chylopoietic tract. One can almost stop digestion by taking thought of it, and the influence of mental treatment and sugar pellets upon constipation can be given objective proof in many instances. The mind has, in fact, quite a lively though incomplete and temporary control over the different functions of the body, and it can, after years, do some damage to them. It can check and change secretions, indirectly thicken arteries, cripple functional activity, and hurry on old age. But after all, the mass of people are sick with tuberculosis, rheumatism, bronchial and heart diseases, and the infections and the injuries of life.

As the mind can help on disease, so it can help on its cure; but a healthy person cannot by an act of his mind make himself crazy; and neither can he by any mental influence, if crazy, make himself well. It has been proved beyond any question that persons who have severe and profound degenerative traits cannot be cured by psychic suggestions.

Hypnotism, for example, is powerless against the insanities after they have developed, it is powerless even against the minor psychoses that are long established and of severe type, such, for example, as chronic hysteria, the long-established obsessions, vicious mental habits, and severe degeneracy. What is true of hypnotism is true of all forms of mental therapeutics, and all types of charlatanry that appeal to the imagination. It may be noticed that the quack and the exploiter of marvelous cures never starts a psychopathic hospital or offers to work in an insane asylum. When the mind is a little enfeebled, over-sensitive, or untrained, it is easily worked upon by emotional influences and suggestions; when it is sound, and trained by education and experience, and when it is seriously disordered, it is not affected by these agencies. Psychic measures of treatment, on the whole, find their legitimate field in internal medicine, among those who have the minor symptoms and functional disorders in which the mind is simply needing instruction to a new point of view, or the stimulus of a strong hope which fixes attentions and steadies the whole mental machine. Psychic therapeutics often cure by giving faith and purpose to the weak, wavering, and discouraged. And faith in something is always a sane and most helpful element in a person's character.

So far as psychiatry is concerned, we can expect little help from the science and art of psychic or hypnotic therapeutics. Its field is narrow and does not take hold of our serious cases.

So far as internal medicine is concerned, mental influences produce many distressing disorders of function, which may simulate various diseases. The mind is a factor always in modifying the picture of disease, and the physician can never diagnosticate or treat his patient without taking the individual's mental attitude into account. This fact, which psychiatrists learn, can be impressed with advantage on the followers of internal medicine.

Psychiatry and Neurology and Internal Medicine

In the past the field of work of the psychiatrist has been perforce much narrowed through the necessities of psychiatric administration. It was long confined to the study of types of mental disorders which had reached their height and shown their hopelessness. It was as though pulmonary tuberculosis had been mainly studied in its third stage, or typhoid fever mainly in its second week, or heart disease after dropsy had set in. For when a psychosis is fully developed and has bloomed into mania, or a dementia, the morbid condition has arrived, the god is no longer behind the machine, but on it. It can now be watched and its natural history studied, but in 75% of cases this is all; it cannot be cured. In only a small percentage will it be possible to learn why it came, and psychiatry can only reach a certain stage of progress when its study is limited to the middle and terminal parts of mental disorders.

The field of psychiatry needs thus to be broadened by securing the help of those branches of internal medicine in which the earliest phases of mental deterioration and disorder show themselves. It was long ago noted that neurasthenia might be called an abortive paranoia. It is my experience that about a third of the cases of decided melancholia are preceded by attacks of what is called nervous prostration; and the same is in a measure true of the early demential psychoses and of paresis.

In fine it seems to me that a most fruitful practical field just now for clinical study is that of what I term the minor psychoses which includes a vast number of indeterminate mental conditions, classed as neurasthenias, hysterias, phrenasthenias, obsessions, impulsive manias, and mild melancholic and hypochondriac states. These patients now fall into the hands of the general practitioner, who is wearied and unimpressed by them, and who fails from lack of interest to study them, or into the hands of specialists who treat their reflexes, generally without avail, or into the hands of neurologists who deal with them generally as having a temporary neurosis instead of a psychosis or the thing out of which one may grow. It is to be hoped and expected that the follower of internal medicine and the neurologist will study the cases more seriously, and from the point of view of the psychiatrist especially. In this way we shall be able to learn the very earliest symptoms that suggest the oncoming of mania and dementia praecox; we will learn better the type of infancy and childhood out of which it grows; we shall learn how to check and to prevent it.

An illustration of such help of neurology and syphilology to psychiatry is already shown in the development of our knowledge of general paresis. This disease was recognized a hundred years ago. Its etiology was not even distinctly suspected till fifty years ago. An established connection of its relation to lues is hardly more than ten years old, this being worked out by the coöperation of the syphilographer, the neurologist, and the psychiatrist. New features of its course, particularly the physical symptoms and early symptoms, have been derived within a few years largely through the help of psychiatrists, neurologists, and syphilographers working together, until now the onset of disease is recognized almost before it is present. By reason of this its course has been checked, and it is my belief that cases have been permanently arrested in their progress, so that we may now say that paresis may sometimes be aborted, if not cured. All this has been done through the coöperation of alienists, neurologists, and syphilographers.

So it seems to me a like coöperation will enable us some day to cope with mania melancholia, chronic melancholia, and the precocious dementias. In this work we must have the help of the practitioner of children's diseases, of the general practitioner, and of the educator who studies the growing child.

A great deal of work has already been done in measuring children, studying their growth, their mental activity and reactions, but not much has yet been formulated which is helpful to us as psychiatrists, to foresee a coming psychosis.

This field needs further study from the anthropologist and the doctor of infancy and childhood. We do not want to know alone that a child is nervous, excitable, easily febrile, a bad sleeper, and a noisy dreamer. But what are the special symptoms which may lead us to foresee a dementia praecox at eighteen, or an hysteria, or a mania melancholia before adolescence, or a paranoia at maturity?

Psychiatry, Pathology, and Physiologic Chemistry

There is an increasing conviction among psychiatrists that some inherited defect, often most subtle and difficult to recognize, is present in all those who develop mental disorders without some original weak spot in the psyche or soma, the man who is infected will not get paresis or tabes; the man who has fevers, toxemias, shocks, and emotional crises, will not get a delirium or insanity.

But the weak point in a degenerate constitution may not be especially in the nervous system. It may be in a glandular defect or insufficiency. One can imagine a person having congenitally defective adrenal glands; as a result, the blood-vessels are not kept at their proper tonicity, and widespread defects in function follow. In the same way, there may be defective or overactive thyroids, and the tonus of the nervous system is disturbed. There is no doubt that the large colon has important functions in selective absorption, and to an extent in secretion. It is an organ that seems especially attuned to cerebral states. It goes wrong at times with every one, but if it is congenitally wrong, if it is born wrong, it is then one of the stigmata of degeneracy. Thus a person may have a psychosis, because he has congenital defect in the colon or other organs than his nervous system; the brain may be a very good one, but these adrenal organs — the thyroids, the blood-making organs, the enteric membrane, the liver — may be fundamentally defective or the circulatory organs may be badly developed.

Now it will be the part of the clinical pathologist and chemist as well as of the anatomist to search out these factors, and in this way help the psychiatrist to steer his way in the future.

I do not believe that the results of this work can be very fruitful as regards the severe dementing forms of mental disease; here there is always fundamentally a fault with the brain in structure or function. But in the functional and non-dementing psychoses, such as mania and melancholia, and in the minor psychoses, such as hysteria, many types of neurasthenic insanity, we may expect much help.

Insanity, on the whole, is not a very curable affection. It is probable that less than a fourth get permanently well, and its rate of cure is therefore less even than that of pulmonary tuberculosis, pneumonia, or the infective fevers. Nor is it likely that the percentage of cures will ever be a very high one.

We may look to the sciences of pathology and chemistry, however, for some help in this direction. It has been already shown that in degenerative disease of the nervous tissue there is the perverted metabolism, which leads to the breaking-up of the lecithin, the important fat constituent of the nervous substance, into poisonous by-products, neurin and cholin. These circulate in the lymphatics and blood-vessels and irritate and further poison the nerve-centres. So that when the brain actively degenerates, it produces a poison. This poison reacts on the nervous centres, causing new symptoms, and thus a vicious cycle is set up. Some of the crises of paresis and the dementias may have this origin.

The function of the lower bowel seems to have some close relation with the functioning of the nervous centres, and an autotoxemia is perhaps an important element in both depressive and maniacal states. Indeed the appearance of mania especially suggests an auto-intoxication. One cannot observe the apparently causeless recurrence of mania and melancholia without the conviction that behind it all is a disorder of metabolism leading to a toxic state.

We may expect, therefore, much from the further studies of the physiologic chemist. Such studies will include the activity of the ductless glands, the adrenals and thyroid, and in particular of kidney.

We cannot, it is true, expect to find any objective explanation of the tendency which the alienated possesses to pass repeatedly into states of mania. But we may find the nature of the nutritional change that excited it, and by proper methods we may be able to keep off recurrence of insanity.

This it seems to me is a hopeful field of therapeutics which is now presented to alienists.

The clinical pathology of the blood has as yet been of little help in psychiatry. The examinations throw no light on the cause or type of a psychosis. Nor do clinical pathologists promise us much here. If we could find and cultivate the germ of syphilis, a field would be opened. At present there are no biologic blood-tests that help us. It seems as if the ingenuity of the investigator would some day in some way show us objectively some blood-changes, for example in acute mania or delirium — yet it has not been done.

Pathologic anatomy is a subject of more academic than practical interest to the psychiatrist. The burden of our work should now be away from morpholgy and more in physiologic lines.

Psychiatry and Criminology

The relation of psychiatry to criminal anthropology is a close and important one. There is on the one hand the instinctive or hereditary criminal, and on the other the moral imbecile and the insane who do criminal acts perhaps casually or as an accidental product of violence and delusion. It is for the psychiatrist to help in solving the difficult problems of the border-line cases. As a rule we can say that the criminal's act has a definite motive, and that his crimes are to his temporary or apparent advantage. The moral imbecile, on the other hand, is in most cases a person whose acts are done without rational motive, or are to satisfy only some morbid feeling, perhaps remotely sexual, perhaps something not easily defined, a kind of atavistic lust-hunger.

But no definite laws can yet be laid down. Each case must be studied by itself in the light of our best clinical knowledge of what constitutes an insane mind. We must bear in mind in doing this that society cannot on the one hand afford to be cruel, and on the other it cannot afford to set aside easily individual responsibility.

For the purpose of securing the ends of justice in any of these cases, such laws as have been enacted in Maine, New Hampshire, and Vermont, and especially in Massachusetts, are best calculated to help on the aims of justice. These laws authorize the prosecuting attorney or judge to place the accused in a hospital where he can be under constant surveillance of physicians, trained experts, and attendants.

The Massachusetts law, for example, reads as follows:

"Chapter 219, Section II. If a person under indictment for any crime is at the time appointed for trial, or at any time prior thereto, found by the court to be insane, or is found by two experts in insanity designated by the court to be in such mental condition that his committal to an insane hospital is necessary for the proper care or for the proper observation of such person pending the determination of his insanity, the court may cause him to be committed to a state insane hospital for such time and under such limitations as the court may order."

Psychiatry and Forensic or Legal Medicine

Forensic or legal medicine as a separate branch of science seems in a way to have died out. It used to be systematically taught in a number of our medical schools, but the chairs have been abandoned. This is not because the subjects which are dealt with have ceased to be of importance (from 1894 to 1899 there were 854 contributions to the forensic medicine), but because they have been assigned to different specialties — the chemist, pathologist, psychiatrists, neurologists, and lawyers. Forensic medicine has been broken up into special branches and hardly exists any more as a particular department of human knowledge.

Psychiatry has much to do with the law, however, and some forensic medical knowledge may be considered almost a part of the requirement of a psychiatrist. Happily, the harmonious coöperation of law and medicine in the professional activity of the alienist is an object that has been fairly well attained, so far as regards the care and guardianship of the insane is concerned. Thus, the matters of commitment, detention, guardianship, discharge are problems fairly well solved in many states, and their discussion is not in the sphere of my address. I can but express the hope, however, that the tendency of legislation will be to lessen the restrictions and simplify the legal methods connected with the care of the insane. It should be easy to get into a hospital and easy to get out. The insane should more and more be considered as sick persons, which they are, and treated as nearly as possible on such lines, both by the doctor and the lawyer.

Psychiatry and Anthropology

The results of the work of anthropologists of the Lombroso school have been fruitful to penology and the saner and more rational dealing with criminals; but they have so far not been of much help to the psychiatrist. The elaborate measurements and observations which have been made show a larger number of anomalies and marks of deviation from the normal in the insane as a class than in the healthy. But these stigmata are never sufficient of themselves to justify one in saying that an individual is defective, or degenerate, or insane.

In some very marked types of insanity they are practically absent. This is especially true of insanities that develop late and have slight dementing tendencies. Insanities with decided moral defect, such as those known as original paranoia, or moral insanities, those characterized by obsessions and compulsions, also show often few stigmata of degeneration. Those with decided intellectual defects and dullness have a large percentage of physical marks. Such, at least, has been my observation.

The science is still young and it should receive the support of psychiatrists. This is being given in some hospitals of this country. An anthropologic laboratory, even if but a modest one, should form part of the equipment of the psychopathic hospital. And observations should be made not perfunctorily and in accordance with some limited conventional plan, but with great attention to detail and with minds open and ready for advance and change. The simple accumulation of fifteen or twenty measurements and notes has been done until it has nearly fulfilled its usefulness.

The foregoing remarks do not lend themselves to recapitulation. I have endeavored to show some of the relations of psychiatry to its nearest allied sciences and to indicate the lines along which work can be carried with mutual help to all, but to the special advancement of a sounder knowledge of that capstone of all the medical sciences, the pathology of the mind.

THE PROBLEM OF PSYCHIATRY IN THE FUNCTIONAL PSYCHOSES

BY EDWARD COWLES

[**Edward Cowles,** Professor of Psychiatry, Dartmouth College, since 1886; Clinical Instructor in Psychiatry, Harvard University, since 1888; Non-Resident Lecturer in Psychiatry, Clark University, since 1904. **b.** Ryegate, Vermont, 1837. A.B. Dartmouth, 1859; A.M. *ibid.* 1863; M.D. Dartmouth Medical College, 1863; College of Physicians and Surgeons, New York, 1863; Fellow by Courtesy, Johns Hopkins University; LL.D. Dartmouth College, 1890; Medical Corps, United States Army, 1863–72; Resident Physician and Superintendent, Boston City Hospital, 1872–79; Medical Superintendent, McLean Hospital, 1879–1903; Consulting Physician, *ibid.* 1904. Member of the American Medico-Psychological Association; American Neurological Association; American Psychological Association; American Association for Advancement of Science; Associé Etranger, Société Médico-psychologique, Paris; American Academy of Medicine; Massachusetts Medical Society.]

In the study of mental diseases it is important to find their true place in relation to other pathological conditions. Our conceptions of the nature of mental symptoms should be framed in harmony with the true principles of general pathology. These are essential requisites for the progress of psychiatry. I shall try to present some considerations to this end in discussing my subject: "The Problem of Psychiatry in the Functional Psychoses."

It is essential here, as in all such inquiries, to have a clear understanding of the terms of the problem; words and phrases, and the formulae of principles, should have correct and definite meanings. Our ideas may be embodied at first in words which seem to express exactly all that we know; but as our conceptions tend to outgrow their verbal expressions, these may gain the larger import and lose the narrowness of their derivations; or being used in an earlier and more or less restricted sense they hamper thinking in the shackles of authoritative phrases that obstruct reasoning, and single words may perpetuate error and lead to confusion of interpretation and discussion. The dicta of general principles accepted as fundamental may sometimes harbor hidden fallacies and prove to be untrue after having long retarded progress. It is a necessary part of this discussion to examine first some definitions and the formulae of certain accepted principles and the doctrines drawn from them.

The terms in which the present subject is expressed contain no ambiguity as to its meaning to lay down the proposition that the problem of psychiatry is to be found in the functional psychoses, meaning here mental diseases. But something needs to be said defining the true province of psychiatry; and the words "functional psychoses" lead at once into the maze of difficulty surrounding the relations of functional and organic diseases. In the definition of disease, as "any morbid deviation from normal health," "the important distinction is drawn between organic or structural diseases in which there is a lesion or pathological condition of some part of the body, and functional diseases in which there is an irregular action of a part but without organic abnormality." But keeping to this distinction it is a remarkable fact that the word "psychosis" is used in opposing senses in mental physiology and mental pathology. The psychologists, having regard to the normal processes, use "psychosis" as "equivalent to the mental or psychical element in a psycho-physical process, just as neurosis refers to that aspect of the process which belongs to the nervous system." On the other hand, in psychiatry the word "psychosis" is used pathologically and "designates an abnormal mental condition;" it is described as a typical form of insanity ("disease-form") which can be scientifically differentiated and correlated with a specific "disease-process," and the usage implies a structural change. In neurology "neurosis" is also changed from its normal functional sense in psychology and used to designate a "morbid or diseased condition." "Functional neurosis is a morbid affection of the nervous system known only by its symptoms, and without anatomical basis. It is doubtless true that an anatomical lesion of some kind does in each case exist, and the classification of diseases as organic and functional is but a concession to our ignorance."[1] These instances afford examples of looseness of usage in two most closely interdependent lines of research showing the disharmony between them that tends to confusion of understanding. It is allowable to speak of the neuroses, and the meaning is plain as referring quite exclusively to functional disorders; but to constitute a true psychosis, in the pathological sense, it must have a definitely differentiated symptom-complex that can be designated as a "disease-form;" this is commonly spoken of as a clinical "entity," and it implies a correlated "disease-process." We may speak of acute and chronic psychoses, or of organic psychoses, to distinguish the insanity due to cerebral disease. But the psychoses proper being conceived as real disease-entities, when in psychiatry we wish to speak of the group of minor and often temporary variations of the mental functions, parallel or corresponding to the neuroses in neurology, the word functional must be added and the term functional psychoses used as in the subject of this discussion.

[1] Baldwin, *Dict. of Philos. and Psychol.*

The Position of Psychiatry as shown by Current Teachings

The point of view of this inquiry is that of general medicine for one who, without predilection and looking for light on all sides, approaches the field of psychiatry and tries to understand its problems. In seeking the true place of mental diseases in relation to other pathological conditions, and in order to harmonize his conceptions with the true principles of general pathology, it is found at the outset that the functional psychoses are to be regarded as being in contrast with the psychoses proper associated with assumed structural changes and "disease-processes," or with definite organic diseases of the brain. Here as in general medicine this distinction of functional and organic disease appears to be an expression of the dominance of morphological conceptions in medical knowledge. Diseases due to obvious structural changes can be understood and subjected to treatment as in surgery; but the bodily diseases called functional for which there is no pathological anatomy constitute a very large group.

Although there is a greater reason for this being true also of functional mental diseases, the inquirer finds in the psychiatry of the time small interest in them. It is a very old idea that the different forms of insanity may be explained by the study of the brain and its degenerations. The history of modern psychiatry shows that it has given great emphasis to these morphological conceptions by its precise methods and achievements in histological investigations of the brain. In recent years the German schools have been the centres of interest. The environment of their origin had preëminently the morphological stamp. Thus the effort to determine definite "disease-forms" and "disease-processes" has been a distinctive characteristic of modern teachings in the search for anatomical correlations and explanations. The application of the scientific method in clinical study has been most fruitful of admirable results. The "disease-process" assumption has been stimulating and helpful as a spur to morphological investigation, which all agree should be carried to the utmost. But with the inheritance of such conceptions the modern movement has been characterized also by the continuance of the quest for mature forms and types and for their systematic classification. The pathological principles being embodied in the designations "disease-form" and "entity," and "disease-process," the consistent use of these has implied that every such pathological process should have its cause, course, and outcome. A psychosis thus constituted is held to present the attributes of scientific truth, although some actual morphological characters that furnish complete and proper proof may yet be wanting.

While these teachings have been taking form in the last twenty years, the influence of modern psychology has been felt and is becoming apparent, especially in the last half decade. Although psychological studies of mental functions are viewed with much of the same distrust as before, the experimental method, in its clinical use in psychiatry, excites interest by the objective character of its results; they have the value of observed and measurable facts of function which may contain the promise of being ultimately traceable to facts of structure.

The present results of this movement are exceedingly interesting and promising, although it is true that there is much diversity in the products of these methods of study. With the increasing number of observers the more variations there appear to be in the interpretation of phenomena. This is shown in the differentiation of named "disease-forms," and by a comparative study of some new classifications.[1] This, however, is a hopeful stage of progress. In the extreme view it has been held to be unreasonable that any conclusions can be drawn from the psychical activity of a diseased brain; psychological explanation is of no value, it is said, without an objective measure in definite "disease-processes" in the cortex. According to other views, in which the conceptions of a "disease-process" is still fundamental, conditions that do not lead to deterioration are conceived to be of a "special type," and a "biological entity" is conjectured as representing "a special kind of disease-process or disease-principle." Again under broader conceptions it is held that more than one point of view is needed to do justice to psychiatry, and a special psycho-pathology is founded upon normal psychology. But this meets with criticism as giving undue prominence to psychological distinctions inconsistent with a true medical conception of disease.

The influence of the new German schools has been strongly felt in other countries. But the inquirer, extending his survey in these directions, finds that the contemporary interest in the physiological aspects of psychiatrical problems has not waned, though they are somewhat overshadowed. In Italy, for example, Ferrari has studied the pathology of the emotions, as has Féré in France, where Ribot has done the most to elucidate the relation of mental experience to the personality, and Janet has made his remarkable contributions to future psychiatry by the analysis of mental instability in the borderland of insanity. The British alienists have conservatively given attention to functional as well as to anatomical conceptions, notably Mercier. Hughlings Jackson has magnified his distinction as a neurologist by his recognition of the importance of the

[1] Meyer, A., *A Few Trends in Modern Psychiatry, The Psychological Bulletin*, vol. I, 1904.

physiological factors in nervous and mental disease; his method of reasoning from functional characteristics to interpret structure, instead of inferring function through proofs in structure, is now attracting renewed interest.

These English views have long held a like formative place in America where they have not lost but have sustained their force during the decade since the introduction of German teachings. Attention was first attracted especially to Kraepelin and the methods at the Heidelberg clinic with a consequent intensification of interest in morphological conceptions qualified by clinical observation. The painstaking studies of Meyer and Hoch approached the subject from the neurological side loyal to the scientific method; through their work the conceptions of Kraepelin were submitted to the tests of practical coöperative study and experience with results anticipating his own later simplifications of "disease-forms." There was also, not only the establishment of collections of admirable clinical records, valuable for further study and analysis in future, at the McLean Hospital and the Worcester Insane Hospital where this special work began, but the extension of this clinical method to many other hospitals. Later in the movement came the different interpretations of psychiatrical problems by Wernicke and Ziehen, — the latter with an especially hopeful attitude toward psychological explanations. There has appeared a tendency to change in the views of these German teachers, of whom it is said they "have emancipated psychiatry from the peculiar position of an adjunct to neurology," — a position for which the claim has long been made and is not yet yielded.

In the outcome of the decade in America the intensity of the new teachings is being qualified by independent studies of the problems involved, and the continuity of the current of earlier views here has been maintained. This former trend has persisted not only in psychiatry but it has appeared in neurology which was formed in, and has held to, pronounced morphological conceptions. Dana, Putnam, and Prince, for example, have taken special interest in the physiological and abnormal aspects of mental phenomena. Herter has made the most noteworthy of contributions to the future understanding of mental as well as nervous diseases, by studies of the chemistry of pathological physiology and the disorders of nutrition and metabolism in seeking the fundamental principles of practical therapy. Traceable here, as in general medicine, is the influence of the immensely important work of Chittenden; while this has little or no place in German teachings of neurology and psychiatry, the chemical side of the composition and activity of nervous tissues is receiving attention in England, in recent years, though the special studies of Mott and

Halliburton, which, however, relate distinctly to changes in structural disease. In America, the trend toward functional conceptions of mental pathology became embodied, with a special motive inspiration from general medicine, in the work of the McLean Hospital more than two decades ago. Early in this period, under the added influence of the new teachings of physiological chemistry, the purpose was developed which has led, in the last half decade, to Folin's chemical investigations of disordered metabolism in immediate connection with the clinical study of the physical conditions and treatment of the insane; the parallel development, on both physical and mental lines, of the original purpose there is also finding its prime expression in the recent establishment of another clinical laboratory in which Franz is applying the physiological and experimental methods of the trained physiologist and psychologist. This particular development of the tendency to studies of the physiological aspects of psychiatry has been characterized throughout by its essential purpose of seeking guides for treatment of the physical conditions associated with functional mental disorders.

It appears that the turning-away from the barrenness of histological provings is becoming general; the improvements of the clinical method and psychological experiment are inevitably drawing attention to the closer observation of the individual patient, and to the better study of the minor causes of his mental variations; this means a trend toward physiology. It is a safe prediction that pathological physiology is to be called to render such aid to psychiatry as it is giving in general medicine; and that the extraordinary advances in pathological chemistry will become available in mental diseases.

Such are some of the considerations suggested by a survey of the present aspects of the field of psychiatry. The changing attitude of psychiatry toward psychology is of great significance. These circumstances guide the inquiry into the conditions and causes of the present position of psychiatry.

The Relation of Psychiatry to General Medicine

Psychiatry belongs to general medicine.[1] This view has been presented in the annual reports of the McLean Hospital since 1882;[2] my first statement of it, in the report of that year, was to

[1] Cowles, E., *Advanced Professional Work in Hospitals for the Insane*, *Am. Jour. of Insanity*, vol. LX, 1898; *The Mechanism of Insanity*, *ibid.*, vols. XLVI, XLVII, XLVIII, 1889–91; also *The Shattuck Lecture, Neurasthenia and its Mental Symptoms*, 1891, *Bost. Med. and Surg. Jour.*; *Mental Symptoms of Fatigue*, *Transactions*, N. Y. State Med. Assoc., 1893.

[2] Cf. *Annual Report*, 1882, 1889, *et seq.*

the effect that the physiological basis of the treatment of the insane lies in the fact that the normal functions of the cerebral organ may be only temporarily disturbed or only partially impaired, whether by transient disorder or pathological change; and the consequent fact that, in most cases, some degree of normal function remains. This principle was stated to be in accordance with the most important gain of modern pathology, the modern conception that "Disease is, for the most part, normal function acting under abnormal conditions."[1]

Mental diseases, in their study and treatment, include more than is contained within one branch or department of general medicine by having to deal with the mental effects of pathological conditions of the whole body; psychiatry is not limited especially to the nervous system with its central organ, which has functions of a wholly different and higher nature than those of any other organ. There are functions of the brain other than the common ones of receiving impressions and reacting uniformly upon them like a reflex mechanism; by its mental function it receives impressions, retains and recalls its conscious experiences, selects from and rearranges them, and in new and orderly forms initiates and controls the processes of motor expression. The psychiatrist newly attempting the precise study of mental symptoms is confronted at the outset with the oldest of problems, the relation of mind and body. If he turns to physiology and neurology for light upon the physiological terms, mental and physical, of his problems he meets everywhere such statements as that of Wundt: "In matters psychological the naturalist can only affirm that psychological phenomena run parallel with physiological facts, but that on account of their different natures he has no prospect of ever bridging the gulf between the two." Edinger [2] writes, "We have no idea how it happens that a part of the work done by the nervous system leads to consciousness." Lloyd Morgan[3] offers the following practical conclusion: "One of the difficulties is that of conceiving how mind can act on matter, or matter on mind. . . . Let us at once confess our ignorance of the nature of the intimate relation of the one to the other. But certainly in many cases the observed facts show that, our ignorance notwithstanding, they *are* somehow related. . . . And since we cannot know the nature of the relationship, let us be content to seek for some of its conditions."

The psychiatrist is a physician who should take his point of view in a field even broader than that of general medicine in its

[1] Dr. Gairdner, *Presidential Address, Brit. Med. Psych. Assoc., Jour. Ment. Science*, 1882.
[2] Edinger, L., *Brain Anatomy and Psychology, The Monist*, vol. XI, 1901.
[3] *Relation of Mind to Body, International Quarterly*, vol. VI, 1902.

largest sense, and not within the narrow limits of any specialism which may seem to include the sphere of mental activities. He has to deal with the physical effects upon the individual of all the influences that act upon him in his environment, and that enter into him from without, or are engendered within, which make for the maintenance or impairment of his vital processes. Such physical influences contributing to conscious experience have their mental effects; the psychiatrist must not only seek to understand the physical changes and effects but he must deal with the patient's consciousness of them; and the more subtle influences that affect the subconscious mental life. The physician must study not alone the influence upon the mind of the body in health and disease, but also the external physical, social, and moral conditions of the environment unfavorable to mental health and growth. It is in association with this broader view of general medicine that, with respect to mental disorder, he must seek explanation on the physical side of the organism, and turn to expert research for such aid as can be given him by the contributing sciences.

The field of the medical sciences is as wide as that of biology, which comprehends all the interdependent phenomena of mental and physical life; the abnormal must be referred to the normal. The first recourse of the psychiatrist is to physiology, whose domain is the study of the forces or functions of living matter. There are no symptoms until there are deviations from normal function; without functional activity disease is impossible.[1] On the side of normal life, living substance necessarily presents the conditions of structure, form, and function; these conditions are primary and disease is not necessary to the existence of living substance. Here the general physician finds himself involved in the contention between the sciences of physiology and pathology; the psychiatrist needs first a normal standard in his knowledge of general physiology, and all that he can learn of mental physiology and its relations to its mechanism, structure, and form. Psychology lays open to intimate study the facts of the mental life; on the anatomical side we can know little, and that little explains nothing of the relations between mind and body. It is at this point that the physician must choose his point of view and form his conceptions of fundamental principles. If these are true, they should fit all discovered facts, whether of function or structure, and will lead to advancement of his knowledge; if not true, they lead to conflict and confusion, and obstruct progress. It is necessary to

[1] Cf. Orth, J., *Relation of Pathology to Other Sciences*, *Am. Medicine*, vol. IX, 1905. "When there is no functional activity and thus no deviation from normal function there can be no disease." Published while this paper was in manuscript.

examine the mutual relations of the biological sciences to know their relative value to psychiatry.

The Position of Pathology and its Influence upon Modern Psychiatry

The science of pathology, with the justification of its brilliant achievements, holds itself to be fundamental to the medical sciences. Its elucidation of the phenomena of disease and its results puts it into inseparable relation with life. It claims that its conceptions comprehend all of biology, for on all sides it bears essential relations to the subsidiary biological sciences. Deviations from normal structure and composition of the body, and from the normal functions of its parts, are held to belong to pathology; in this view the study of structural variations in the evolutional and the developmental processes from the normal in primordial and embryonal forms may explain inherited and congenital disease, and, as a part of pathology, throw light upon morphology. Physics and chemistry, as they underlie both function and structure, contribute to the explanation of pathological change, and the disorders of function caused by disease; and pathological physiology and chemistry, whose importance is now receiving growing recognition, are to be regarded as subsidiary to pathology and dependent upon it. In the sphere of general pathology, dealing with function, it finds its duty to be "to correlate symptoms with structural changes and trace the connection between them."

The science of pathology, presenting by its salient aspects such claims to the physician who seeks for light upon the problems of psychiatry, reveals a changing history. The leadership of the pathological-anatomical school in France passing over to Germany culminated in the "cellular pathology" of Virchow, this being founded upon the principle that the cell is the unit of structure and function and that all vital processes are to be referred to the activity of the cells of which the body is composed; they are the "factors of existence." This includes the phenomena of disease and all alterations of the organs and tissues, the principle being that whatever acts upon the cell from without produces a change, either chemical or physical, in the cell structure, and disease is constituted of such changes. These principles became the foundation of the "exact medicine" of the present day. Griesinger first established modern psychiatry upon the exact basis of scientific research and pathological principles, and through Meynert pathological-anatomical teachings were greatly advanced; following them it was in such an environment that the latest schools of psychiatry had their beginnings with an immediate inheritance of its morphological conceptions as the fundamental criteria of scientific truth. Such were the conditions of the inception of the current teachings, based upon a rigid morphology. The German schools of psychiatry became the centres of interest and influence, and their characteristics have already been noted. In the history of the time from Virchow, Griesinger, and Meynert to the present there have been momentous advances in the other biological sciences as well as in pathology and psychiatry. The two latter lines of research are being strongly influenced by the concurrent changes. There are some very recent and significant signs of changing views in psychiatry which possibly betoken the freeing of itself from the too rigid dominance of structural pathology.

The Relation of Pathology to Other Biological Sciences, Especially to Physiology

Physiology, when it declared itself an independent science by breaking away from medicine and establishing its place in the great realm of biology, entered upon a broader field of study of the functional side of life with its complex phenomena in the functions of all living matter. To morphology, as an equally independent science, belongs the study of the structure and form of living matter; it covers the whole field of anatomy in the special forms of zoölogy and botany. But physiology and morphology, which are closely woven together, are both built upon the foundation of the inorganic elements of inanimate matter with its controlling laws of physics and chemistry that govern the forces of inanimate phenomena. All these forces of animate and inanimate nature are bound together; from a biological point of view we do not know living matter without both form and function.

On the part of the physician the inquiry at this point is as to the true relations of pathology to the other biological sciences in medicine. The scientific foundation of pathology, the development of its work in the other sciences which it necessarily involves, support its claim to an equal place in biology with the other natural sciences.

Prof. Orth, in an address at Kassel in 1903, described pathology as consisting of two branches, anatomy and physiology. Although the great Virchow remained a pure pathological anatomist, he contemplated the beginning of pathological physiology as the culmination of his endeavors; "one of his favorite themes was the establishment of pathological physiology, a subject which, to his mind, was the foundation of scientific medicine, and therefore of medicine as a whole." Practical medicine, according to Virchow, is coextensive with pathological physiology; this is founded on pathological anatomy, clinical observations, experimental researches; its problem is the determination and investigation of bodily processes under abnormal conditions, of illness and its symptoms. Virchow's experimental investigations to clear up morphological characteristics of disease go only to the beginning, and Prof. Orth urged that better attention should be given to physiological methods for the determination and interpretation of functional disorders in the unhealthy organ; yet pathological morphology must remain the unchangeable groundwork of all medical knowledge and thought; its most important function is its purpose for the upbuilding of pathological physiology, for the understanding of the living processes and their disturbances in the sick body.

Bacteriology in its marvelous progress leads investigation directly into the field of pathological physiology, and finds explanations in the normal physical and chemical reactions that belong to the normal cell physiology. Pathology, taking bacteriology into its special province, is engaged in the study of problems relating to the nature of disease. General physiology has shown that the physico-chemical reactions in living substances are fundamental and essential factors in the production of vital phenomena; it finds, in its investigation of the component elements of cell-substance, that in physiological chemistry is its chief aid in the explanation of vital activity and its disorders. Herter [1] reviews our present knowledge of the chemical defenses of the organism against disease; it serves to emphasize the varied chemical activities of the cells, and to render more intelligible the phenomena of diseases that result from modifications or failure of these cellular functions. He says: "Modern pathology has made us familiar with the conception that disease is generally the expression of a reaction on the part of the cell to injurious influences. The only rational conception of the ability of the human body to defend itself against disease by means of chemical agencies is that these defenses ultimately reside in the cells themselves. Many of the phenomena of disease are caused by the modification of function that occurs during the action of the cell in resisting injurious influences." Ernst [2] has shown that, notwithstanding the great obscurity of the subject and the somewhat conflicting theories, the point is maintained that in all reactions the cell activity intervenes at some stage of the production of immunity; and that most probably the reactions that occur are closely related to these that go on under the ordinary conditions of tissue metabolism. These considerations are consistent with the fundamental doctrine of cell physiology and pathology.

It appears from a brief survey of the history of pathology that when at first it was part of anatomy, it was then preëminently morphological, and that this characteristic motive still prevails to a

[1] Herter, C. A., *Chemical Pathology*, 1902.
[2] Ernst, H. C., *Modern Theories of Bacterial Immunity*, 1903.

large degree. After it became independent, pathology concerned itself especially with deviations from the normal anatomical standard. It developed new relations with the other biological sciences as they attained existence, and like morphological problems arose in connection with them. There was mutual receiving and giving of aid, but anatomy was the parent science and the study of the concrete facts of structure being easier than ever-changing function, morphological conceptions have always kept in advance and pathology has held them to be essential in giving finality to its explanations and proofs. But with the slowing of progress, as normal and pathological histology has approached the frontiers of present attainable knowledge, much of speculative theory has arisen in the endeavor to prove apparent and conjectural realities of structure by reference to the facts of physiological activity. The history of pathology reveals evidence in support of the conclusion that, from the beginning, the science of pathology has needed first the data of normal form and function in order to study their deviations; also pathology has been steadily tending to the finding of its ultimate dependence upon physiology. Aside from the results called disease from actual traumatism of cell bodies caused by extrinsic agencies there must be many transient conditions of intracellular rearrangements or molecular disorder, beginning with functional and defensive reactions, long before there can be any ascertainable structural findings. Such molecular changes, beyond the ken of the microscopist, might be assumed to be structural in fact; but the ultimate problem of the search for explaining principles thus tends to become a physico-chemical one. The facts of cell functions should hold an important place in the study of the varying agencies and influences of cell stimulation in the production of symptoms. The relation to physiology of the morphological side of pathology is especially instructive.

The Relation of Morphology, Normal and Pathological, to Physiology

Morphology presents considerations of the highest importance which require special notice in this examination of the mutual relations of the biological sciences. It is granted that pathology, on the morphological side, is inconceivable without normal anatomy as its basis. Pathological anatomy, being dependent on normal anatomy, belongs to the science of morphology. This science, with its great subdivision of embryology, has attained splendid achievements; in the course of its advancement in many specialized lines of investigation in plant and animal life, it has enjoyed the advantage of being able to study the problems of evolution and development in many quickly succeeding generations of vital forms. The scope of its observations has extended farther than from the point of view of medicine, and is reaching conclusions that may yet illuminate some of the dark places of psychiatry. The history of morphology has a special significance in its development cotemporary with other biological sciences; the changes in its course suggest a law of progress in scientific research that has operated in other fields. After the emergence of morphology, and of physiology, from the keeping of anatomy, the two new sciences entered upon equal domains in the realm of biology. Morphology asserted the independence of the science of form and structure from that of function; the doctrine was that form persists and function varies. It was characterized by the conception of a fixity of types, a rigid adherence to the study of mature forms which it labored to arrange in a perfected and systematic classification. With the breaking-away from these rigid conceptions, during the last fifty years, the course of progress was in the study of the problems of evolution; leading through the investigations concerning the origin of species, it has come to the recognition of the supreme importance of the problems involved in the development of the individual, and of the biological laws that govern it; and the wide range of variations that may be produced in members of a given species. So in medicine, instead of clinical types, the differentiations of disease are becoming genetic and developmental in character.

In the morphology of plant and animal life it is agreed on both sides that they are subject to the same laws; in both plants and animals there are identical processes which are consistent with the significance of the cell doctrine as being fundamental to morphology. In the close relation of form and function the modern conception is that the structural characters of which an individual organism is made up correspond to its functional characters; form characteristics cannot be understood without considering the function characteristics. Physiological characteristics are transmissible in the same way as the morphological. The study of physiological cytology and embryology is revealing the mechanism of the transmission of qualities; with the aid of the experimental methods in the production of variations in both form and function, there is great progress in the understanding of the laws of descent and inheritance. The close relation of physiological and morphological characteristics proves that the problems of form and structure are also physiological problems. Physiological processes are influenced and often controlled by the conditions of the environment both internal and external; and it is shown that mental as well as physiological characteristics are inherited under the same laws. These brief references to the data of morphology serve here to indicate the trend of progress in this science; it points to the conclusion that influences which stimulate functional activity play an essential part in determining the processes of development and the resulting structural forms. The demonstrations of the dominance of the sensory over the motor side of the nervous mechanism is consistent with the fact that all movements are primarily a response to sensory impressions and are performed under their guidance. It follows from the teachings of Hughlings Jackson that cell-groups are thus formed by a process of education. All motor phenomena being responsive reactions to stimuli applied to the neuro-muscular mechanisms, the laws of use and habit influence functional activity and growth. The unity of all these sciences is also shown. Physiology and morphology have to do with interdependent manifestations of organic existence; there can be no disease until there is first normal life with whose physical sequels pathology has to deal. Inasmuch as the whole science of pathology must refer all its material to normal standards, both on the functional and the morphological side, a like freedom belongs to the minor province of mental pathology; psychiatry is at least justified in seeking directly its immediate explanations in the hopeful though neglected field of function.

The Pathological Conceptions of Psychiatry stated in Terms implying Morphological Ideas

In such a survey as this, of so complex a subject, certain difficulties have appeared concerning special aspects of current effort, in the field of the psychiatrist's labors. Allusion has been made to the remarkable fact of the disharmony between mental physiology and mental pathology. There are signs of the coming of better coöperation, but so far the general fact is that the psychiatrist borrows from psychology what seems fitting with his pathological conceptions, and applies some of its psycho-physical methods; at the same time he hesitates to use the data and even the terminology offered by expert investigators in mental physiology. The importance of care in the use of descriptive words has been mentioned; an inquiry like this draws special attention to this subject and some extraordinary facts are revealed that should receive further notice.

First among these may be mentioned the use of the word physiological; its frequent infelicitous employment by both pathologists and psychologists themselves emphasizes the width and depth of the traditional gulf between mind and body. The distinction is commonly made between *psychical* phenomena and *physiological* phenomena and the designations "mental side" and "physiological side" are used to make the same contrast. Mental phenomena are themselves physiological, but the usage implies a distinct psychical element as an extra-physiological epiphenomenon, when such a meaning is not intended, and is therefore misleading. The mind event and the brain event are both physiological.

More remarkable examples of doubtful usage, universal in medical literature, and with far-reaching effects, are shown in the words "disease-form," "disease-entity," "disease-process," and "pathological process," which have already been mentioned. These words still suggest old meanings now wholly obsolete; this is so obvious that when thoughtful writers use such words "for convenience," the explanation is not infrequently made that it is not intended to imply that disease is a malign entity which invades the living body and works its evil course. Yet, as usage sanctions it, writers continue to employ the framework of words which would once have expressed the ancient parasitic personification of disease. While, in the science of pathology, this extreme conception is corrected by explanation, such words in their modern usage still embody and positively convey the sense of an underlying morphological counterpart of the symptom-complex that runs its course of progressive degeneration as a disease and reveals the terminal changes in post-mortem findings. To speak of all disease in terms used in these senses is to emphasize structural conceptions of pathology, and thus to impede the progress of the reform which is clearly seeking to give adequate attention to functional conceptions in place of the dominating demand for mature types and forms and classifications.

It would be interesting to follow out the history of the usage of these verbal embodiments of whole theories. Perhaps a reference to main points will be enough to indicate the purport of these observations. First, as to the nature of disease, it cannot be correctly conceived as a state of disordered activity or disorder of a process in an *active* sense; there is a condition produced by a defensive contest between the forces of the living cell and the harmful agencies; it is not a state of perturbed activity but the result of it in diseased organs or tissues. The causes of disease are extraneous and unnecessary to cell-life, which can exist without disease. The only true *process* in living organisms is the physiological, or life-process; the forces that cause the reactions called vital phenomena are inherent and are governed by the uniform laws of an invariable order of nature; like effects result from like causes and conditions, and the life-process presents the attributes of uniformity and continuity controlled by the laws of descent. Reproduction is an original property of living matter and life is continuous, and death is not due to such a property; this is a proposition in which there would be a general agreement with Weissmann. Roger [1] reduces the conception of death to the formula: "Death is the result of an arrest of cellular nutrition; whatever the multiple proceedings are that are called into play, the final result is always the same."

A "disease-process" or "pathological process" cannot be con-

[1] Roger, G. H., *Introduction to the Study of Medicine, Trans.*, 1901.

ceived as comparable with the physiological process; the causes of disease being extraneous to normal cell-life are accidental, multiple, discontinuous, without uniformity. It is consistent with this that even in the problem of tumor growths there are some essential explaining facts; whatever of the various theories may be employed to account for them, they are not in dwelling entities, but depend for their existence upon the inherent vitality of the parent organism acting under abnormal conditions. When the organism dies the new growth dies; there can be no disease without prior normal life.

When applied to functional disorders, the assumption of a necessary correlation between a "disease-form" and an underlying structural "disease-process" goes beyond the province of morphological pathology; it involves the intracellular changes of physiological chemistry. It is obstructive of a true conception of the wide variations of function that belong to molecular nutritive and metabolic changes due to variations in condition, irritability, intensity of stimulus, etc., though affecting the same physico-chemical operations by the same agencies. But an authoritative insistence upon the "disease-form" and "disease-process" ideas, with respect to all psychoses, has undoubtedly tended to distract attention from a free consideration of functional conceptions of mental pathology. These and kindred forms of words, with their distinctly morphological stamp, show the character, in some degree, of changing conceptions of pathology. They are kept in use by their convenience; and they appear to be in harmony with certain accepted theories and doctrines concerning the nature of disease and death, and their relation to life. The influence of these doctrines is so great as to require examination here.

The difficulty of determining a sharp limit between life and death has been stated by Verworn:[1] there is no definite time at which life ceases and death begins in a complex organism, for one set of cell-complexes may survive another for a long time; but "there is a gradual passage from normal life to complete death which frequently begins to be noticeable during the course of a disease. Death is developed out of life." "Thus death does not come to the cell immediately, but is the end-result of a long series of processes which begin with an irreparable injury to the normal body, and lead by degrees to a complete cessation of all vital phenomena." It is reasoned that "life and death are only the two end-results of a long series of changes which run their course successively in the organism;" also that "death undergoes a development; normal life upon the one hand and death upon the other are merely the remote end-stages in this development, and are united to one another by an uninterrupted series of intermediate degrees." This transition from life to death is

[1] Verworn, M., *General Physiology, Trans.*, 1899.

termed *necrobiosis*, a word introduced into pathology by Virchow and Schultz; it is understood to mean, according to Verworn, "those processes that, beginning with an incurable lesion of the normal life, lead slowly or rapidly to unavoidable death."

Thus the principle of necrobiosis is to be studied in the cell as well as its vital phenomena; and it is held to apply also to the death of compound organisms. By an extension of this conception it explains the condition of natural death in old age, which thus appears to be physiological. Senile atrophy, which leads finally to death from the feebleness of old age, is to be regarded as simply the end-result of a long developmental series; death in old age is the natural end of an unbroken development and its causes exist in the living organism itself. Life itself never becomes extinct, but there is a continuity in its descent; yet living substance itself, in the form of bodies, is continually dying.

Compare with the foregoing the views presented by Gowers [1] in regard to "diseases from defect of life" to which he gives the designation "abiotrophy" to distinguish a newly differentiated clinical group of conditions and symptoms; he acknowledges Mott's cotemporary recognition of these conditions. The conception is that of "a degeneration or decay in consequence of a defect of vital endurance;" it indicates a failure of life-processes due to defective vitality which seems to be inherent. It is recognized that many degenerative diseases of the nervous system are a result of such defect. The idea is expressed by Mott: [2] "The neurones of a particular system die prematurely, owing to an inherited or acquired want of durability, and the regressive process of decay may be looked upon as a nutritional failure on the part of the same cells to maintain that metabolic equilibrium essential and correlative to functional activity." Every nerve-cell of the human body is conceived to be "endowed with a specific durability whereby in the health-perfect organism every neurone possesses an equally adjusted vital energy." This is a statement of one of the two ways in which the regressive process occurs, the other being "the metamorphosis incidental to old age manifested by a gradual and general enfeeblement of the functions of the whole nervous system." "In contradistinction to this normal senile decay are the premature pathological processes of decay attacking groups, systems, or communities of neurones subserving special functions." "The process may be regarded as the inverse of development;" in harmony with these views Hughlings Jackson is quoted in regard to the helpfulness of considering diseases of the nervous system "as reversals of evolution, that is, as dissolution." Mott conceives that the process of primary degeneration is, morpho-

[1] Gowers, W. R., *Abiotrophy, Lancet*, 1902.
[2] Mott, F. W., *The Degeneration of the Neurones, Croonian Lectures*, 1900.

logically, an evolutional reversal commencing in the structures latest developed.

In the extensive literature concerning the life-processes and their failure in disease and senility other diverging views may be cited, but the purpose here is only to indicate certain ideas and reasonings that bear upon the pathological conceptions with which psychiatry has had to labor. With respect to physiological old age ending in natural death the contending view is that the decline of life manifests the summation of the effects of external injuries, the damage of wear and waste, and is not something different and apart from disease. It is to be noted in the doctrine of necrobiosis that the idea of a "disease-entity," with its course and process parallel and antagonistic to the life-process, is avoided by conceiving life or the life-principle as the sole producer of two series of developmental processes, one of which leads to its end-result in the existence of normal being; this life-process is also conceived as turning against itself in another process of producing a series of decrements that reaches to the end-result of non-existence. One result must exclude the other, and we admit that death is the common goal; the life of every living thing ends in death and there is only one end-result, — death is developed out of life. But by shifting the position to the larger view the attempt is to set up a dual conception of two processes, equal, parallel, antagonistic, yet conjoined. The truth is that the whole of life comprehends all living nature; the individual parts that bloom, fructify, and perish, and the fragments chipped and sloughed off from the great embodiment of life in matter, are always dying or dead, but the one chief process of life goes on, and we say that life is developed out of death. The minor casualties of injury and disease represent the chance encounters of living substance in its struggle for existence with the discontinuous opposing forces of the world of living and material things. Living substance dies, but life is immortal. We may describe, in such figures of speech, the dual developmental processes with their contrasting end-results.

The paradox of the "processes" appears also in the application of the doctrine of abiotrophy which, of itself, helps to make clearer the terms of the problem by the conception of a failure of nutritional energy with a consequent limitation of the durability of the organism and of the length of life. In applying this doctrine to certain pathological changes it is said that the overgrowth of interstitial neuroglial tissue, when the nerve elements decay, is in consequence of the fact that the two elements have "a common but inverse vitality;" when the nutritional energy fails to maintain the growth of both, the more highly specialized tissue ceases to live, while the less specialized tends to overgrow with the tendency of the former to decay. It is explained that these "tendencies are in the opposite direction, but they seem to be coincident results of the same vital condition."

In the many well-known conditions of constitutional weakness and instability it is easy to understand the nutritional failure to develop normal growth and efficiency of function, or to maintain them, and the consequent recession of the developmental processes, even to the cessation of life. The doctrine of dissolution as characterizing the many conditions of such recessions is clearly consistent. When biological conceptions are invoked, it is also easy to comprehend the general principles of development whereby, through physiological reactions of the organism, there are adaptations and modifications of characters due to changes of environment and favorable to life and health; it is intelligible that through use higher types of characters may be produced, or through disuse recessions to more primitive types, under the causative influences of the environment, and all this may be within the physiological limits of the organism as expressions of the processes of life. In the domain of biology it is, no doubt, helpful for descriptive purposes to conceive of the developmental forces as acting in an inverse direction, producing the effects of reversals and regressions. But when this latter conception is applied to pathological conditions, it is in harmony with our prevailing modes of thought in medicine that there is conceived to be an attack, as of some harmful agency, upon the living organism; a pathological process of degeneration is supposed to ensue which is a regressive process of decay, and this implies its active going backward against the normal tendency of the nutritional energy to maintain life and growth. As a further explaining principle the conditions of acquired or inherited defect are conceived, and a process of degeneration of which "heredity" is the motive force; thus the developmental forces turn against themselves, and, working in the inverse direction, produce decay. It is the all-pervading disposition to seek an immediate cause for every effect, and it is easy to describe agencies and processes. When the stamp of "degeneracy" is fixed upon a fated organism we commonly think of its possessor as a "degenerate" descending to inevitable doom.

Is it not evident that there is a misleading ambiguity in the prevailing usage of the conception of "processes"? It is necessary to the notion of a process that there is a passing over of one set of phenomena into another, and this constitutes a change.[1] A "process" is constituted of a series of such changes when one stage or aspect of the process necessarily succeeds upon another. The action of a causative force or stimulus is essential to the change, as in the biological processes. The requirements of the concep-

[1] Baldwin, J. M., *Development and Evolution*, 1902.

tion of two coincident processes appear in the principle of the psycho-physical parallelism in the relation of mind and body. It being the general fact that certain changes in those brain- and nerve-processes with which consciousness is associated are always accompanied by changes in consciousness, and the converse being true also, then certain other scientific principles are involved: (1) the principle of *equal continuity*, with no breaks in either series of changes, — if one series is continuous the other must be continuous also; (2) the principle of *uniformity*, when certain phenomena in each series in brain-process and conscious state are essentially associated, then the concomitance of those terms may be looked for on all other occasions; (3) the principle must be a *universal* one, — whenever we find a series of phenomena in either of the parallel trains of events the principle of parallelism has its application. Structure and function must exist before there can be any disease; the phenomena of life represent the supreme process in animate nature; the phenomena of disease and degeneration appear as the results of discontinuous interferences with the life-processes in which "normal function is acting under abnormal conditions;" the assumption of a "disease-process," or of a "pathological process" in the same sense, fails to meet the essential requirements of a "process," — it is certainly not comparable with the life-process. If we must speak, for convenience, of "pathological process" and "degenerative process," the terms should be used only in a very narrow sense of comparatively transient interferences, or in the sense of referring to normal function acting pathologically.[1]

To the inquiring mind the contradictory presentations of these matters is confusing and creates difficulty. The subjects are, in their nature, complex, and our knowledge is limited, but much ambiguity is undoubtedly due to the lack of precision in the statement of the terms of the problems. One of the most common obstacles to clear thinking appears to arise out of the fact that for every predicate implying action we have to think of an actor, or causative agency, and our minds habitually conceive of some form of personification of such an agent as possessing motor and motive attributes. Thus we think of life and death, and artists picture them, in human forms; we are prone to dualistic conceptions and the mind delights in such paradoxical phrases as, there can be no death without life; no disease without health; no evil without good. The use of the active predicate abbreviates expression

[1] The writer's views of the inadequacy and misleading influence of the "disease-process" conception as a question in psychiatry was first presented to the American Medico-Psychological Association at its meeting in Washington in 1902, in an unpublished paper on the principles of mental pathology and the nature of mental symptoms.

and enlivens speech. Professor Sanford,[1] discussing the influence of physics on psychology, notes the fact that, as the result of man's long primitive practice, his habits of thought are objective, and the language he uses is saturated with physical connotations and metaphors. It is not easy for even the best of us, he says, to keep clear of this inveterate physical-mindedness and the subtle suggestions of language; we help out our thinking by material figures and feel a sort of dumb compulsion to make our psychological theories accord with physical requirements. Ebbinghaus is quoted as describing the older psychology as distinctly "mechanistic," many analogies from familiar material processes being used in the exposition of mental phenomena. In regard to essentials, Professor Sanford thinks it may be said that psychology has outgrown this method. But turning to our own field of the medical sciences, the ruling tendency of our thought and language leads to the conceptions of "disease" and "process," for example, in terms implying immediate causative agents. The familiar conceptions of a process of anabolism and a contending process of katabolism in the cell are treated as the analogues of the life-process and death-process. The analogy is extended to include in this conception the fact that in the whole compound organism the anabolic processes overbalance the katabolic till middle life, when the two processes are more nearly in equilibrium, and that thereafter katabolism predominates more and more in the normal decline of old age. It is held that in the broadest sense the process of senescence begins with the beginning of life in a progressive diminution of the power of growth; and with the progressive waning of the vital powers the leading somatic changes accompanying old age are atrophic and degenerative. The same conception concerning the anabolic and katabolic processes is equally legitimate concerning the idea that an inherent tendency to degeneration is transmissible; the inherited constitutional weakness and diminution of vitality may be interpreted as belonging to the series of changes which imply a process of dying continuing through several generations.

There appears through all these reasonings the prevailing method of thinking in terms of "processes." The inquirer is moved to ask whether the normal processes of anabolism and katabolism are not both essential to the maintenance of a health-perfect cell and both, therefore, parts of the normal life-process? We do not think of the most healthily active cell as one most vigorously dying. If we consider the physico-chemical changes in the cell inclusively as a process of metabolism, it is consistent to think of the normal building-up and breaking-down of complex compounds in growth, work, and repair as harmonious, and not antagonistic, operations.

[1] Sanford, E. C., *Psychology and Physics*, *The Psych. Rev.*, vol. x, 1903.

Hering separates assimilation as only a qualitative chemical change from growth as quantitative, and in like manner dissimilation from atrophy. As to the transformations in the cells and the overwhelming number of substances excreted from them, little is known of the processes by which these are derived; but many products are formed in both the ascending and descending portions of the metabolic series. Disordered and imperfect adjustments of the molecular arrangements of living substance may affect and arrest both anabolism and katabolism; defect of the latter and not its predominance can be conceived as a cause of the death of the cell.

In physiological theory the distinction is made between death of the tissues and somatic death: in the former, it is reasoned that constantly throughout life the molecules of living matter are being disintegrated and whole cells die and are cast away, — and that life and death are concomitant; in the latter, death occurs when one or more of the organic functions is so disturbed that the harmonious exercise of all the functions becomes impossible. This distinction has been referred to, and further inquiries are suggested here. In respect to the death of the tissues, the "unit cell," being an organism of high complexity as to its structure and function, and its life-process, is not failure of this life-process of the coöperative adjustments within the cell truly analogous to the failure of life, or somatic death, in the whole compound organism? In this connection the question again arises as to the concomitance of the processes of life and death, — the latter being theoretically analogous to the constant disintegration of living matter. Hering's idea that assimilation and dissimilation are distinctly separate from growth and atrophy permits the former to be regarded as one intimately combined and normal metabolic process in a working cell, having no theoretical significance except as wholly contributing to the maintenance of the function of a health-perfect cell. The daily shrinkage of the working and fatigued cell may be regularly made up by rest and nutrition; this is not atrophy, either simple or degenerative, for the continuity of cell-life may be unimpaired and only the labile molecular inclusions be changed by normal use which promotes the health of the cell. On the other hand, the function of growth, being of a more primitive type, would appear to contain the explaining principle of the life-process as contrasted with the work-process. Consistent with this appears to be the sharp differentiation by Adami between cells which have the habit of growth and those which have the habit of work; these two functions cannot be exercised by the same cell at the same time, and a normal working cell may revert to the type of a vegetative cell. This implies that cells of the primitive type having only the function of growth, their "work" (in the common usage of the word) is without external manifestations of energy; but that the function of work, which is the power to store potential energy within and to produce kinetic energy in external work, belongs to the highly specialized cell as an acquired character which it may lose. This being true we may understand that assimilation and dissimilation, in the limited sense employed by Hering, constitute a special kind of inclusive metabolic process different from the molecular changes, perhaps less complex, productive only of growth. It is not conclusive that katabolism typically represents destruction of life, though it means changes of substance in which life exists. These considerations suggest questions that are not in harmony with the generally accepted theory of life and death as concomitant processes based upon an assumed analogy to the physiological processes of the healthy living cell.

This inquiry is intended only to consider some examples of current theories with the question whether they can be resolved into more simple conceptions. The life-process being conceived as the one supreme "process" in living organisms, this implies its maintenance by causative forces; assuming each individual to be endowed with a given vital durability, determined by antecedent conditions and subject to modifications due to favoring or adverse influences, the life-process reaches its possible attainments and finally fails in the struggle for existence. Injury, interference with normal function, overuse and disuse, disease, and the causes of the changes of senility present alike adverse influences which the organism fails to overcome. We must speak of disease and use its meaning as referring to results in diseased parts, organs, or tissues; and we may commonly think of the word as implying a combination of disorders of functional activities which may or may not be associated with ascertainable structural changes. But it should be remembered that we are thinking of a patient and not a "disease." There is no disease-process; no causative forces exist in nature that induce and carry on processes of degeneration and decay; gradual failure is the summation of the failures of community work due to the complexity of the organism, each organ being subject to the harmful influences of the functional failure of other members of the community. There may be deterioration of function, and degeneration of structure in the sense of failure to maintain it; there may be also regressions or rather recessions of results, but no active pathological "process" of going backward in the structural reductions called "degenerative." These considerations do not support the idea of a "physiological old age," based upon the conception of a normal process of degeneration or decay as though the results of senile conditions in structural changes are different from disease. This doctrine of natural decay and death makes great trouble in dealing with senile conditions in medicolegal cases; and in like cases concerning degeneracy in earlier life the most contradictory and confusing notions prevail. They are not in harmony with practical experience. This is largely due to the adoption in psychiatry of generalizations in regard to heredity not yet warranted by the science of biology. The morphological ideas in the prevailing pathological conceptions, and the descriptive terms employed, have undoubtedly obstructed the progress of psychiatry. From all such preconceptions the psychiatrist should be wholly emancipated.

A functional conception of pathology is not in conflict with a pathological conception in the sense of the long-used distinction between functional and organic diseases. The objection to this is not lessened, but the fault is not with function. Life and the science of physiology are first; function and all that pertains to it are primary facts of the activities of normal life. Much disharmony in the conceptions of pathology has been due to the setting-up of ideas of "organic diseases" as the chief factors in pathology, and the minimizing of function as worthy of serious scientific consideration. Our conceptions of function are uncomplicated as relating simply to the modes of action of the several parts of the organism; but we must think of organic disease in two ways, of changes of structure in results, and of changes of action in "process." The functional factors are necessary to organic disease and their distinction and true relation should be discovered in their combination. The organic changes of disease are the sequels of interferences with the prime process of normal life.

Physiology and its Relation to Psychology

Physiology acknowledges its debt to Johannes Müller, who mastered the two great sciences, morphology and physiology, and was a teacher of pathology. He took an active interest in psychology, regarding physiology by empirical methods as essential to advancement. After Müller's death, nearly fifty years ago, the fields of his scientific work were divided by the specializations through which the present marvelous advancement has been gained. Physiological chemistry became independent of physiology; and physiological psychology developed on the lines of psycho-physical experiment. It was then that mental physiology should have made its union with mental pathology. It is easy to see that psychology tried to accomplish this by its attempts to find a morphological basis for its investigations through the experimental method, but the field for this was limited. Psychiatry under like limitations, by its morphological attitude, met the invitations of psychology with inherited distrust of a functional pathology; psychology was turned upon itself, and also, much of its own choice, sought and found open ways back into the attractive regions of the investigation of psychical function and philosophy. The later phase of psychiatrical interest in experimentation has been mentioned, and is full of promise, but such movements require years of time. The method of exhaustive study of the clinical expression of psychical reactions through speech and behavior, and the use of experimental tests which bring out individual characteristics and their variations, are gaining a share, which must increase, of the attention and interest heretofore centred in the pathological laboratory. This is a new and definite revelation of a tendency toward the study of a functional conception of pathology in psychiatry.

Psychology is still kept apart, however, from the practical study of mental pathology; this is probably, in part, its own fault; although some students of psychology have shown the requisite interest, there is a lamentable want of opportunity. What would really be the most promising interest in psychiatry should be found in the establishment, in hospitals for the insane, of true experimental psychology, with physiological methods applied clinically, according to the principle of using instruments of precision in other clinical work.[1] The observer of these clinical manifestations trained both as a psychologist and physiologist would find many new variations of phenomena not seen in the normal subject. A hospital for the treatment of mental disorders is a laboratory of itself where nature makes experiments in the excitation, suppression, and combination of naturally correlated psychical and physical reactions, giving many clearer displays of their nature, both by their intensification and absence.

Mental diseases are peculiarly and essentially constituted of mental symptoms; the study of their phenomena must refer them to mental physiology, for the laws governing vital phenomena under abnormal conditions are not different from those of normal life. The study of mental physiology under pathological conditions should be helpful for both psychology and psychiatry.

This inquiry being assumed to be free from all preconceptions as to the true nature and place of mental pathology, and as to forms and names of mental diseases, it may be turned to an ex-

[1] For an account of the beginning of the present laboratory methods, both psychological and chemical, at the McLean Hospital in 1889, see *Les Laboratoires de Psychologie en Amérique*, by E. B. Delabarre, *L'Année Psychologique*, 1895; also *Laboratory of the McLean Hospital*, by G. Stanley Hall, *Am. Jour. Insanity*, 1895. The subsequent development of the pathological laboratory and the clinical methods, — of the laboratory for pathological chemistry in 1900, — and of that for pathological physiology and psychological experiment in 1904, constitute a true psychiatrical clinic of a special character, designed from the outset for the investigation of the functional conditions of mental disorder.

amination of the relations of psychology, or mental physiology, to all of the associated reactions of the physical organism. This is the necessary basis of pathological physiology for psychiatry. Approaching the subject newly from this point of view the physician should seek to inform himself concerning at least the immediate facts of mental function and the accepted postulates of psychology. But in preparation for such a study it should be recognized that mental physiology is included in general physiology as concerning a part of the vital activities of the living organism; also that certain general modes of action in the body always have a part in mental function. Some of the symptom-factors of mental disorder have their genesis in conditions that affect primarily other parts of the organism than the brain. General physiology therefore claims the attention of the psychiatrist to certain essential principles whose importance can only be indicated here by mentioning some of those of immediate interest; the purpose is to present some of the physiological reasons for the proposition that the problem of psychiatry lies in the functional psychoses.

References to Physiological Principles

A distinctive feature of modern biology is the fundamental conception of a living body as a physical mechanism (Huxley); underlying all the phenomena of the animal organism is the reflex action of the nervous system, and physiologists generally agree to consider every action as aroused by some cause or stimulus (Sedgwick); under the biological conception man is an organism for reacting on impressions (James). The nervous and mental mechanisms being regarded as constituted of three minor ones, their action appears in a sensory, — a central or transformation, — and a motor process; in the central process part of the work done by the nervous system leads to consciousness; the response to a stimulus may be a muscular contraction, a secretion in a gland, a vascular change, or even a trophic or metabolic influence, — all pertaining to the centrifugal system. While reflex action is not conscious action, one may be conscious of the act, and in many cases conscious changes precede, accompany, or occasion the change. The most important reflex of all is commonly ignored, viz., that which provides for the constant readjustment of the parts of the system to each other, by virtue of which the entire mechanism is receptive even to minimal stimuli. This may be termed the *neuro-equilibrium reflex.* The tone of the nervous system is this wonderfully complex adjustment of inhibition and stimulation. Every metabolic process in all the nerve-cells exerts its influence on the entire nervous system. One of the most remarkable reflex associations is that between vaso-motor alterations and the seat of the emotions, which are thus intimately involved with the viscera and vessels in their minute connection with the sympathetic system. This association has a most important influence in the mental sphere, though beyond this fact little is yet known of the physiological basis of these reactions.[1]

The intimate connection of mental states and the physical reactions of the whole body is well recognized by both physiologists and psychologists; it is of fundamental importance in psychiatry. Lombard[2] describes the cells of the central nervous system, during waking hours, as continually under the influence of a shower of weak nervous impulses, coming from the sensory organs all over the body; moreover, activity of brain-cells, especially emotional forms of activity, leads to an overflow of nervous impulses to the spinal cord and an increased irritability, or, if stronger, excitation of motor nerve-cells. There is a constant inflow from the environment of a vast number of excitations ordinarily disregarded by the mind but all the time influencing the nerve-cells; the effect of this multitude of afferent stimuli, in spite of their feebleness, is to cause the motor cells continually to send delicate motor stimuli to the muscles and to keep them in the state of slight but continued contraction or tension of *muscle-tonus*. In these mechanisms is the seat of the kinesthetic sensations and the functional alterations that play so essential a part in contributing to the well-known symptom-factors of the "sense of effort" and "inadequacy," and motor "retardation" and "excitation."

Some of the physiologists have given much study to the relation of mental and physical states. Sherrington's[3] discussion of common and organic sensation and the contributing cutaneous sensations has an extraordinary interest for psychiatry. Common sensation is understood to mean that sum of sensations referred, not to external agents but to the processes of the animal body, and these sensations possess strong affective tone. Total common sensation is the result of many component sensations, and those that arise in internal organs and viscera contribute a great deal to the total sum. Affective tone is the constant accompaniment of sensation; every form of common sensation is based on perception of an altered condition of the body itself. In connection with this comes the fact that all forms of common sensation present significantly preëminent attributes of physical pleasure or physical pain; and all are linked closely to emotion.

[1] Cf. Baldwin's *Dict. of Philosophy and Psychology.*
[2] Lombard, W. P., *The General Physiology of Muscle and Nerve, Am. Text-Book of Phys.*, vol. II, p. 143.
[3] Sherrington, C. S., *Cutaneous Sensations*, Schafer's *Text-Book of Physiology*, vol. II, p. 969, *et seq.*

The elaborate researches of many observers in recent years concerning the nature of the muscular sense, the senses of touch, pain, and temperature, and their special mechanisms, strengthen the common fact that their sum contributes to the effects upon mental feeling-tone. They are in their nature productive in part of the organic sensations. Ribot [1] has studied, more than any one else, the psychology of the emotions and the logic of their mental and physical reactions; he describes the presentations in the conscious mind of organic sense as constituting a vast aggregate of impressions arising from within the organism and continually flowing towards the superior nervous system; it is this region of subject consciousness that gives the consciousness of being, — the sense of personality. The sensations from the special senses are intermittent, of high intensity, and small in volume compared with the voluminous though faint, continuous, and all-pervading commotion produced by the organic sensations. These are intense enough, however, to be susceptible in health of psychical interpretation as a sense of well-being; from their disorders and intensification comes the sense of ill-being. These are the long recognized changes of coenesthesia. Professor James has shown the intimate relation of the emotional tone to bodily states; and Professor Ladd makes clear the usefulness to psychiatry of a study of the affections and emotions in their relations to the train of ideas, and to the different bodily organs; also the reflex effect of the changes in these organs upon both the feelings and the ideas.

Underlying all these physiological phenomena of the living organism is the primary attribute of irritability. All the functional phenomena being influenced, within normal limits, by changes of irritability in the central, peripheral, sensory, and motor mechanisms, and these changes being dependent upon the processes of nutrition and metabolism, and upon conditions of use and disuse, rest and fatigue, etc., the alterations of functional efficiency in the associated reactions of mind and body make the study of cellular physiology imperative for psychiatry. Some of the most commonly observed and characteristic symptoms in mental diseases may be referred to such functional disorders in the physical organism.

Physiology and its Relation to Psychology, continued

The healthy organism being fully constituted in structure and function for its work, when put in use begins immediately to be subject to modes of action which are the effects of its own activities; in other words the living organism acquires functional characteristics

[1] Ribot, Th., *Diseases of the Personality, and the Psychology of the Emotions.*

as the immediate effects of use. Some of the common physiological laws have a special importance here because they govern the work of the physical mechanism and therefore of all correlated mental reactions, not only in health but in disease, as long as any functional activity continues.

(1) *Association* and *Habit* are fundamental in mental life; in respect to the association of ideas it is not the ideas that associate but the elementary processes of which the ideas are composed; on the physical side the law reduces to the law of habit (Titchener). Memory is an associative process; mental reactions (including perceptions, ideas, emotions) are associated with their physical correlatives and motor consequences. Habit is closely related; it is the functional disposition to repeat organic processes. This law of association and habit applies to "organic memory;" thus "associative memory" is fundamental in, and unites, both psychical and physical reactions.

(2) *Inhibition.* The animal organism has a motor character. All sensations and mental states are motor; the entire neuro-muscular organism, mental and motor, acts primarily as a whole, governed by the laws of association, and this is subject to control. "The phenomena of nervous life are the outcome of a contest between what we may call inhibitory, and exciting or augmenting forces" (Foster). It is conceivable that all nerve-centres are normally at all times subject to continuous control or inhibition, and are maintained in a condition of mobile equilibrium by the opposition of this inhibition to their own inherent tendency to discharge (Mercier). "Inhibition is an action which obstructs or impedes another action, and which weakens or arrests it if it was already in action" (Oddi). "Voluntary action is at all times the resultant of the compounding of our impulsions with our inhibitions" (James). "The inhibition of a mental process is always the result of the setting-in of some other mental process" (McDougall). It may be said as a physiological conception that in living substance there are conditions of cohesion and inertia by virtue of the anabolic tendency of its physical and chemical elements; this may be called *physiological inhibition*, and it is the primary factor in the mobile equilibrium conservatively holding the balance against the tendency to discharge induced by constant external stimulation. The psychological conception of the essential physical fact is that one neural process inhibits another; it may be said that as a will-impulse implies a neural process which may inhibit, or excite and augment, some other mental or neural process, this may be called *voluntary inhibition*. The great importance of the study of inhibition, which is only indicated here, lies in its holding an equal and counterbalancing place in mental and physical processes.

(3) *Energy of muscle and nerve.* This refers to the principle of the storage and discharge of energy, and the biological theory that functional activity of a specialized tissue depends primarily upon chemical changes in its individual cells. The fundamental idea is that in the resting state the cell elaborates highly complex compounds and that these break down to yield the energy by which the cell does its work; discharge and restoration of energy is common to both nervous and muscular elements. Hughlings Jackson characterizes the animal organism as "an apparatus for the storage and expenditure of nerve force." These principles are of essential importance in the study of mental disorders. Inasmuch as functional efficiency must be taken as a measure of the available energy, it should be expected that exhausting influences would reduce functional power. Such reductions characterize all forms of the functional psychoses, and the variations of their symptoms are consistent with this principle.

(4) *Physiological use and fatigue, — waste and repair.* The law of use includes the wholesome effects of those just cited; normal use develops functional activity and strengthens power, while disuse weakens function. Overuse begets fatigue, and normal fatigue presents mental as well as physical effects. *Physiological fatigue* may be continued beyond the point of regular recovery by rest and nutrition; it then becomes the *pathological fatigue* of nervous exhaustion or neurasthenia with the characteristic symptom-groups. A functional conception of the significance of these groups of mental and physical symptoms should stimulate not only such a precise observation of them as is needed to constitute "disease-forms" and mature types, but should lead to their being analyzed and traced to their functional sources in the whole organism in accordance with the principles of general pathology. This method reveals the genesis in physical states of some of the most characteristic mental manifestations. Beginning with the fundamental attribute of irritability, for example, wide variations occur within normal limits, but more striking and significant changes appear in all forms of pathological fatigue, and the functional psychoses; the irritable weakness and languor of neurasthenia, and the psycho-motor excitations, retardations, and "confusions" of melancholia and mania are examples. The study of these alterations of irritability involves the whole problem of reflex-action and the mechanism of responses to stimulation of both mental and physical functions. It is to be recognized also that all of these reactions contribute to the sensory returns from the whole organism, — from the viscera, muscles, and even the special senses including the special dermal sensations, to the central nervous system, constituting the kinesthetic and organic sensations. In mental physiology a functional conception of these reactions

reveals their importance for an understanding of the genesis or emotional changes, and the alterations of the affective tone in states of persistent mental depression. The sense of well-being and ill-being depends upon these variations. Most important of all, because so completely neglected in psychiatry, are the bluntings and losses of organic sensations and the consequent effects upon the feeling-tone and ideation; in this regard attention should be called, especially, to a remarkable fact well established in physiology and psychology. It is evident that the normal irritability of nerve and muscle requires the maintenance of a certain chemical constitution; slight variations from this, temporary or continuous, alter or may destroy the irritability. Further, it is noticeable in most cases that the first step toward deterioration is a rise of irritability; the cause being increased or continued, sooner or later exhaustion supervenes, the irritability lessens, and is finally lost.[1] These functional reductions of sensibility, in a wide range of varied degrees and combinations, are constant symptom-factors in psychiatry.

The relation of mental physiology having an essential importance for psychiatry there should be a first reference of all mental symptoms to their functional sources in the organism as far as possible with respect to their correlation and association with alterations of bodily functions. By the genetic method study should begin with the minor changes from normal action; these alterations show intensifications and losses of function, and symptom-groups are modified by their varied combinations.

Mental Physiology and the Functional Psychoses

The true basis of a pathological physiology in psychiatry is mental physiology and its physical correlations of function; variations of nervous and mental reactions in their initial stages may be wholly functional. Approaching the subject newly from this point of view the physician is assumed to know the modes of reaction of the nervous and mental mechanisms and that part of the work done by the nervous system leads to consciousness; he should know also the primary postulates of psychology. Having to study the operations of other minds, he needs to distinguish, in descriptive terms, his own conscious experiences.

A helpful method in psychiatry is to separate the experiences that relate to the outer world from those that belong to the inner life. Professor Sanford presents this idea in discussing the relation of psychology and physics, to which reference has been made. He describes the conscious experiences that may be called physical phenomena: percepts or series of percepts belonging chiefly to the sense-

[1] *Am. Text-Book of Physiology*, vol. II, p. 61.

fields of sight, hearing, and touch, including under the latter the kinesthetic senses as well as pressure, heat, and cold; he speaks of these as the senses that mediate the "life of relation" with the world outside our own bodies, — the "physical group of senses." Taste, smell, pain, the general and organic senses — all having little external reference — are not mentioned at all in physics, except incidentally. The method of psychology on the other hand, while not essentially different, has broader outlines; its phenomena are various conscious experiences, including all those with which physics sets out, but also experiences involving pain, organic and general sensations, feelings, emotions, memories, images, volitions, processes of reasoning — and everything that belongs to such experience. Physics dealing with outer experiences only practically works with terms derived exclusively from the kinesthetic and a part of the dermal and visual experience in its spatial function; these are the senses capable of perceiving matter in motion, and the physicist in using their terms excludes reference to the other senses of the physical group, sight, hearing, and touch. Psychology deals with both inner and outer experiences.

This general view of mental physiology has a special value for psychiatry which it is possible here only to indicate. The conception of a relation between conscious experiences and outer physical phenomena implies an organism, with its special "physical group of senses" in touch with the outer contacts, acting as a medium of transmission between the two; this medium may be conceived as forming also a *somatic* group of senses in the paths of communication. But this mechanism of transmission does not afford, even normally, open ways without friction or obstruction; to its reports of contacts with the outer "life of relation" it adds the multitude of returns with all their variations from its own physical workings, and for this process the same mechanism of kinesthetic and other senses, in a new grouping with others, including the organic and general sensations, is used. In abnormal as well as normal conditions these returns, however imperfect, stand for the truth and the whole truth in conscious experience; in health we think as little as possible of the medium of transmission, and in all conditions of well-being or ill-being we can only describe our organic feelings in general terms. We do not recognize for the most part the sources of these sensations, yet they have a controlling influence upon our minds. These considerations indicate three groupings of the functions of the sensory mechanisms of conscious experiences: (1) the physical group of senses of the outer "life of relation;" (2) the somatic group of senses of the inner life — our conscious experiences of our own bodies; (3) the central psychical life, which includes both of the other groups of conscious experiences, besides those belonging distinctly to its mental aspects. The interest of this to psychiatry is that comparatively little attention has been given to this inner sensory field of the sources of conscious experiences; yet, it may be said, here are the conditions and the very material of bodily and mental stimulations and sensations with which the mental work is done. These explaining principles have been almost wholly omitted from the accepted formulae of the conceptions of modern advanced psychiatry which has chiefly concerned itself with the motor aspects of mental life and expression. These physiological references are needed to explain many of the symptoms of the psychoses and should have their full value in the formulation of the principles of mental physiology and psychiatry.

A functional conception of mental pathology [1] directs observation to the first and smallest departures from normal action, upon the principle that all variations of a pathological character are subject to the laws of normal function acting under abnormal conditions. The study of the development of symptoms is equivalent to noting the genesis and progress of the conflict between the functional energies and the abnormal conditions. Symptoms as functional modifications are the results in changes of action, — organic effects are the results in changes of structure; by the genetic method the sequences of functional phenomena are noted; in the functional psychoses there are variations of functional efficiency manifested by its reductions and recoveries. The following characterization in outline of the psychoses is an application of the functional principles referred to in the foregoing pages. For the purpose of tracing the several orders of symptom-factors from their genesis in functional sources they can be considered most simply under the divisions of the mental elements — intellect, feeling, and will, as these terms are used in modern psychology for purposes of classification.

Characterization of the Psychoses according to Functional Principles

1. The Functional Psychoses. A study of the large group of cases of non-deteriorating mental disorder yields certain general conclusions as to what may result to the normal well-endowed individual when subjected to the effects of use, disuse, overuse, and stress. Beginning with the least degrees of decline of functional vigor, below normal fatigue, there is no point in the declension where a line can be drawn definitely marking a change from one named

[1] Cf. Barker, L. F., *Methods in Medicine*, *Boston Med. & Surg. Jour.*, June, 1905. Referring to the value of a functional conception of pathology, it is also said that "as medicine has become more scientific the mind has ceased to be satisfied with such descriptive classifications as the clinical symptoms and syndromes represent and with 'clinical types' set up, and is ever on the alert to replace them by classifications of a developmental or genetic character." Quoted from an address before the Mass. Med. Soc. published while this paper was in manuscript.

"clinical type" to another, down to the lowest degrees of vital energy and complete loss of voluntary function. Throughout all observations of these changes the essential principle of variations of irritability is never to be lost sight of nor the fact that the first step toward deterioration of function is characterized by a rise of irritability. Another pervading principle is that among the multiple functional mechanisms failure of energy is unequal, and that changes and losses of irritability must apply as much to sensory as to motor function. The word "psychosis" can be used most profitably as correlative with "neurosis," and as including both its proper psychological and pathological meanings, leaving the differentiations of sanity and insanity to be indicated by those words. A basis of inquiry, as above described, prepares the way for the examination that comes first in order of the initial departures from mental integrity, viz., the affections called imperative and fixed ideas, and the primary asthenic conditions of neurasthenia before the after-effects of chronic states have supervened.

Insistent and fixed ideas refer to a wide range of kindred cases of affections that can happen to sound minds in persons neither temporarily nor constitutionally neurasthenic. The functional elements are normal and the affections may attain characteristic forms in normal minds; but this happens to them more readily when there is neurasthenic reduction of inhibitory energy and greater degrees of intensity and persistence occur in association with constitutional instability. All observant sane persons estimate the purposes of others by interpretations of their speech and behavior, and thereto fittingly adapt their own conduct influenced by inferences and judgments in a manner that would indicate "paranoid" suspicion under certain circumstances. Inasmuch as this is a universal, functional, self-protective principle, sane persons have normally the functional disposition to produce ideas of suspicion and persecution, but well-balanced minds control thought and speech. In *any psychosis*, however, associated with asthenic conditions there may be "paranoid forms" not belonging to that psychosis as essential to the symptom-complex; this reaction is liable to become casually intensified or further developed and fixed by habit. In many cases not "psychasthenic," nor physically neurasthenic, the affection is purely a functional accident; it may involve all forms of emotional reactions, other than "phobias," and many cases recover.

Neurasthenia, in its early conditions, uncomplicated by the effects of habit, presents the same elements, in mild degrees of functional reduction, that characterize their greatly varied combinations in the symptom-complexes of the graver conditions of melancholia, mania, and exhaustion psychosis or confusional insanity. These neurasthenic conditions may occur in all persons, under sufficient stress, but when there is constitutional weakness the power of resistance is less. The functional elements of the organism, all working together, constitute combinations of community-work of extreme complexity; these elements being unequally reduced in efficiency the "clinical types" are very much varied. A method of analysis of symptoms with the endeavor to estimate their functional values and their relations to their physiological sources will appear under the following topics:

The functional psychoses constituting the main group of non-deteriorating affections pathologically regarded as insanities, all have a basis of some kind or degree of asthenic reduction of functional efficiency; as already indicated, these may include the whole range of degrees from simple cases of nervous exhaustion downward through the simple and pronounced cases of melancholia and mania, including all varieties of phases and combinations of the symptom-elements; also including the more actively induced exhaustion psychoses and confusional deliria. Functionally considered, it is proper to regard all these cases as "functional psychoses" until proved to the contrary. Function comes first as the present criterion; organic change is a result. Cases carefully diagnosticated characteristically tend to recovery. The designations, neurasthenia, melancholia, mania, etc., are simply valuable descriptive terms; they are thus not correct names of diseases as clinical types and we have yet to study broadly the genesis and development of these conditions. By the functional method we have merely advanced, as yet, little beyond the general fact that two classifications may be made of the psychoses — the non-deteriorating, and the deteriorating. By the morphological, clinical-type method there is a singular lack of success in adopting principles of valuation of symptoms by which men of good minds can reach like conclusions. We are not yet ready to determine species; this should be aided by the study of the genetic character of the symptom-elements.

The significance of the unifying characters of the non-deteriorating range of psychoses may be made much clearer by grouping them according to the functional sources of the symptoms and their own natures. The symptom-factors thus fall into natural groups, which should be studied with complete freedom from preconceptions of "disease-forms." No more is attempted here than to harmonize these groups with the elementary postulates of psychology, and with the general physiological facts heretofore cited.

(1) *Feeling.* (The feelings and emotions.) The emotional variations that are pathologically persistent are in close relation with the changes of bodily states which are represented in the central nervous system by the organic, kinesthetic, and general sensations; the sum of these has, physiologically, a strong influence upon mental feeling,

and therefore in pathological conditions the emotional tone of the psychical sphere corresponds with the sense of personality by "states of mental depression" (melancholia) associated with malaise and ill-being, and "states of mental exaltation" (mania) with sense of well-being and false euphoria. The complex sources of the sense of body have been described and the changes of irritability due to fatigue and other causes; the consequent variations of the sense of physical pleasure and pain are closely connected with the rise and decline of irritability, its intensifications and losses, but not with parallel changes.

In the emotional states of "neurasthenia" the depression is variable; of "melancholia," persistent; in both the feeling-tone may be combined in various ways with the first degree of functional deterioration of irritability marked by agitation, restlessness, "irritable weakness" (psycho-motor excitation), or by dullness, slowness, languor (psycho-motor retardation). In nervous exhaustion and melancholia the feeling-tone is constantly influenced by bluntings and losses of organic sensation, strikingly shown in the loss of the sense of fatigue — "fatigue-anesthesia," and the various unequally distributed conditions described in the natural order of decline as hyperesthesia, hypoesthesia, paresthesia, and anesthesia; also ease and obstruction of motor expression have their reflex influence upon the affective states as in a feeling of facility, or the "sense of inadequacy" and the "sense of effort." [1] Hopelessness, introspection, retrospection, apprehension, self-reproach, are logical consequences. All these variations are persistent intensifications and differences of the normal connections of ideas and emotions, with their correlated physical reactions; the persistence of morbid emotional reactions indicates deteriorated body-states.

In the emotional states of "mania" there is the characteristic exaltation and exhilaration; but in many cases there is depression of feeling of the type shown by anger in its origin from painful states of irritation, and by distressing delusions and aggressiveness. These two prominent types of feeling-tone are associated with corresponding variations of irritability marked by its rise from moderate to high degrees of psycho-motor excitation, shown mentally in "flight of ideas," corresponding to the agitation and irritable weaknesses in melancholia, — sometimes more extreme and sometimes reduced and lost. The clinical pictures in some cases may indicate a simple absence of painful irritation, but they certainly show, characteristically, the false euphoria of blunted sensations, as in alcoholic intoxication.

(2) *Intellect.* (Sensations — perceptions and ideas.) The "thinking process," as it is rather vaguely called, may be definitely con-

[1] Cf. Cowles, E., *op. cit., Neurasthenia and its Mental Symptoms*, 1891.

ceived to include the ideational reactions of the stream of consciousness, constituted of the association-processes in combination with the inhibitory or exciting control of the will working through attention and apperception; the emotional factor enters into the combination and modifies the "thinking process" with intensifications of interest and motive influences. It is impossible to describe these function-factors separately because they all work together. The character of the ideas — the sensations revived by memory in the association-process, whether depressed in melancholia, or exalted in mania, is in harmony with the emotional tone as it is "lowered" or "exalted." The time-element in the processes of the stream of consciousness varies with the rise in irritability and especially with the coincident reduction of inhibition. This, in mania, with the intensification due to irritability, produces "flight of ideas" with quick reactions and superficial associations. The tendency is to increasing weakness, reduction of clearness, incoherence, and final arrest of mental functions in confusion or stupor. With disordered perceptions there are illusions and hallucinations; delusions arise. Maniacal states represent graver degrees of derangement than melancholia, and a lower level of functional reduction, especially of inhibition. The more profound conditions of acute exhaustion (confusional insanity, exhaustion psychosis) occur sharply by themselves from strongly exhausting influences and are varied manifestations of delirium; these may supervene in the severer types of both melancholia and mania.

(3) *Will.* (Inhibition — attention and apperception.) In the sense that acts of the will are such acts only as cannot be inattentively performed it produces exciting or augmenting effects in the "thinking process," or inhibiting effects; working through attention and apperception its function of control appears in voluntary inhibition, and this has been described in part in connection with the other elementary functions and in the reference to the physiological law of inhibition. Normally inhibition, both physiological and voluntary, stands in mobile equilibrium with the tendency of all conscious and neural excitations to discharge into motor effects, open or concealed within the organism. In the incessant change and succession in the train of ideas in consciousness the attention holds the chosen or attracting idea in the interplay of neural processes and thus inhibits its tendency to pass away, other items being held with it in reasoning, and apperception being a special form of the same controlling influence. This inhibitory function is a true index of the integrity of vital energy; it is regularly reduced in efficiency with asthenic reduction of the nervous forces. Voluntary inhibition is variably reduced in neurasthenia, persistently in melancholia, and greatly so in mania with loss in delirium.

(4) *Organic Sensations and States.* (General and kinesthetic sensations.) The importance has been shown of these function-factors of the "somatic group of senses," in respect to the representations they bring into conscious experiences concerning the inner physical life of the body. In health the sensory and motor reactions of our bodies, and our conscious experiences, are adjusted to contacts with the environment within normal limits; the organic and kinesthetic senses normally contribute to the general welfare with only salutary interferences, and these being mostly unnoticed we habitually ignore their existence. It is in disordered physical conditions that the abnormal influences arise and interfere with and derange the experiences of the mental life; they are general and vague in character, but are of essential significance, though only described as subjective experiences. The phenomena of changes of excitability and loss of function are well known and variously described; an interference with the functions of any one system will disturb the normal functional equilibrium that must of necessity exist in the action of the whole.[1] The principle of localized variations of irritability, as in the neuroses, applies to all functioning groups of cellular mechanisms; the threshold of excitation may be raised or lowered in any of the sensory, motor, or central and psychical parts of the reflex mechanisms. Upon these changes may be predicated all the phenomena of psycho-sensory and psycho-motor excitation and retardation, conditions that appear in some kind or degree in the whole range of the functional psychoses. These variations may be ascribed to reductions of the nutritional maintenance of the vital energies. Hyperesthesia and hyperkinesis are the complementary manifestations that betoken fatigue, or equivalent weakness from some cause, of the physiological inhibitory energy; this condition is often associated with anesthesia of the fatigue-sense in the same case.

It should be noted that the changes of feeling-tone, of motility, and of control do not run parallel to each other; hence the differences of the clinical pictures presented by typical melancholia and mania, and the so-called "mixed cases;" melancholia presents two principal types — emotional depression with excitation and retardation; mania presents emotional exaltation with excitation, and sometimes there are painful states of consciousness and the acute reductions of function in exhaustion and stupor. There are numerous phases in the unified melancholia and mania as constituting one general group of variations of functional disorders presenting clinical phenomena apparently widely divergent as "clinical types," but falling into harmonious relations when explained consistently with their developmental and genetic character.

[1] Cf. Mott, F. W., *The Degeneration of the Neuroses.*

2. The Deteriorating Psychoses. These psychoses have an important relation with the *functional psychoses*, which should be mentioned here. They are characterized by persistent functional deterioration and tend to dementia; this is consistent with the opposing fact that the vital energies of the life-process sometimes appear to overcome in recovery the interferences with their normal action. It has been said that the functional psychoses tend to recovery; yet the failure to recover in some cases may be consistently referred to constitutional weakness or the loss of vigor in old age. This does not imply that heredity is an essential cause of mental disease; "neuropathic" persons have less endurance against all adverse influences. Among the *deteriorating psychoses* the first place is given to a large group called "dementia precox;" its general form is not clearly differentiated, nor its special divisions; no common basis is implied in the designations hebephrenia (mental weakness), katatonia (motility disorders), paranoid forms (insistent and imperative conceptions). A single case may change from one "form" to another, and the recognition of some constant characters is required to unify all the "forms;" the common fact of dementia is shown in the deterioration of capacity that may occur in any of the functional mental elements, varied in different cases; this implies structural changes. The character of the failure is revealed in the quiescent states after the subsidence of active symptoms. The most common fact is the deep-seated deterioration of the emotional nature; hence the characteristic indifference and apathy which favors the development of habit automatisms, etc. Concerning this large group of deteriorating psychoses, regarded as above stated, and including also the few other "disease-forms" at present accepted as such, some general conclusions now appear with respect to the functional psychoses.

Mental Physiology and the Functional Psychoses, continued

The unification of the functional psychoses can only be indicated here with respect to the explanations and conclusions reached during some years of teaching the principle that each of the groups conveniently designated neurasthenia, melancholia, mania, etc., simply includes variations in combinations of different degrees of functional disorder of the same physical and mental elements. The essential unity of melancholia and mania was recognized by Griesinger and others with differing explanations; modern physiology and psychology broaden and simplify the whole subject with better explanations of general principles.

In recent psychiatry there is an evident tendency to the unification of the psychoses.

A significant contribution has been made by Dana;[1] in his large neurological experience he has seen much to favor the idea that most neurasthenias are mental cases, or non-insane psychoses; the term phrenasthenia is used for a special group of neurasthenic or degenerative psychoses including mainly those described by Janet as psychasthenia; it is said that an innate constitutional weakness underlies all the chief non-accidental functional insanities. There is much reason for a simplifying psychiatrical conception, complementary to Dana's view, that not only most but all functional mental cases are subjects of asthenic reduction of functional efficiency and are neurasthenic. The tendency is notable in the remarkable studies of Janet in which he reaches the conclusion by psychological analysis that many of the apparently diverse psycho-neuroses may be unified under the one principle of psychasthenia; this implies a general and special insufficiency in all the phenomena and is at the same time neurasthenia; these affections represent regular degrees of lowering of functional efficiency.

The genetic method leads to a comprehensive view of all the psycho-neuroses. Considered biologically and physiologically neurasthenia, phrenasthenia, psychasthenia and all the functional psychoses are modifications of functional characters. Whether these modifications were acquired newly by the individual himself, or by his ancestor and thereafter transmitted as though they were inherent variations, the problem is essentially the same. However perverted, distorted, and anomalous the functional phenomena of vital activity may be, they must be traced back to the first interferences with the physiological elements to find their explanations in their genesis. We may assume that all normal adult individuals are subject to certain acquirable functional modifications — numerous and complex, thus forming the symptom-groups called neurasthenia, melancholia, and mania, for example; all abnormal persons are subject not only to the same changes, but to something more and something different, and these additions may be simply special variations of intensity, or degrees of impairment, or of differences pointing to other than functional explanations. A general principle in mental pathology may be derived from these considerations. Whatever the form of a deteriorating psychosis, it has its own pathological characters; but superimposed upon these symptom-factors, and relatively superficial, neurasthenic manifestations commonly appear, and there may be episodes, more or less transitory, of manifestations of the functional psychoses. This occurs notably in the early stages of dementia precox and manifests the practical concurrence of two diseases, viz., the per-

[1] Dana, C. L., *The Partial Passing of Neurasthenia*, *Boston Med. and Surg. Jour.*, vol. CL, 1904.

manent deteriorating psychosis and the transitory phases (melancholic, maniacal, and paranoid) of the functional psychosis. This principle accounts also for the fact of there being maniacal as well as melancholic types, and the "paranoid conditions," in the "involution psychoses;" this principle is already well recognized in respect to the neurasthenic, melancholic, and maniacal modes of onset of paresis; and to the same types of functional disorder, and tendency to obsessing suspicious and delusional ideas, in senile insanity in which active symptoms may measurably or wholly disappear. All the psychoses called functional for purposes of classification, and being nearest to normal, constitute the main division of the psychoses (considered as mental disorders); all the psychoses called deteriorating, and being exceptions to the others, constitute the minor division. In these the fact that in some particulars the reductions of functional efficiency remain permanently deteriorating constitutes dementia, which implies some form of structural change, though none strictly characteristic has yet been found. The pathological principle here suggested leads to a practical method of analysis of the symptom-factors of all possible forms of deteriorating psychoses. The first step is the distinction of the purely functional modifications referable to physiological sources; these relate to variations of the fundamental irritability as explanatory of changes of motility and of the sensibilities and emotional tone, all being comprehended broadly in relation with the "somatic group of senses;" closely kindred with these are the reductions of function of the processes of association, memory, attention, inhibition, etc. Holding apart these phenomena of the main division of psychoses as being included in the functional conception of their pathology, and as explainable through their genetic and developmental character, there remain, of the symptom-factors of a deteriorating psychosis, those that point to the causes of the special deterioration. This helps to define the problem of research for anatomical explanations. It should not escape observation that when there is "innate constitutional weakness" in cases belonging to the main group of functional psychoses, special modifications may be noted in the symptom-factors, especially of the attention and inhibition element whose reduction is the most constant and characteristic fact of constitutional insufficiency. It is in these conditions that the law of habit has its most potent and perpetuating influence. The functional psychoses, including those answering to the definition of "a typical form of insanity," present some points of special interest when analyzed in accordance with the method and principles examined in the foregoing pages. Reference has been made to Griesinger's descriptive definitions of melancholia as "states of mental depression" and mania as "states of mental exaltation." During more than half a century these designations have held their places in psychiatry; the search for more satisfactory statements has not been altogether successful. The difference of the emotional tone is the criterion, but it is not a wholly true one. The depression in melancholia is consistent because the "somatic senses" retain enough of normal function to report truly to consciousness the fact of ill-being of the body; but in mania the exaltation is not constant, the physical correlatives of the feeling-tone are more disordered by reductions and losses yielding more irritating excitations and in many cases a fictitious sense of well-being. But the "somatic senses" produce other equally important symptom-factors in the changes of motility; in melancholia with impaired inhibition there are both psycho-sensory and motor excitations and retardations, — in mania, with graver changes and losses of inhibition, motility is more disordered. The word melancholia, by long usage and observation of the facts, really stands correctly in the recognition of its meaning all of its well-known symptom-factors other than emotional depression; the word mania, meaning madness, stands equally well for both its emotional variations and its motor excitement. In mania there is graver derangement of the "thinking process" and its "states" are at a lower level of reduction than melancholia. These references though meager serve to show that the terms melancholia and mania are well understood as including a great variety of states of varied combinations and proportions of their symptom-factors; besides the many typical cases of each group there are found to be very many "mixed cases." There are many phases, and a two-phase conception to represent the original groups of "states" does not hold good; for example, taking out the emotional depression from one group, and the motor excitation from the other, in order to designate the distinction of the phases and to characterize the compound "disease-form," leads to the exclusion from it of the very essential psycho-motor excitation often associated with the depression in the former group, and to overlooking the significance of the emotional changes in the latter. An adequate study of the "somatic group of senses," as suggested here, should help to clarify the whole matter. Compound designations for the unified symptom-groups yet suggested do not satisfy the requirements so well as their simple combination in "melancholia — mania." The psychoses cannot be limited to the insanities; we must speak of the "non-insane psychoses," and in psychology the word refers to normal function. It might be said that the first step in the classification of mental diseases discovers two great divisions: *functional insanity* and *deteriorating insanity.*

This discussion of the thesis that the problem of psychiatry is in the functional psychoses, required first an examination of the terms and conditions of the problem. This necessitated an inquiry concerning certain principles and conclusions of the biological and medical sciences that have had a controlling influence in psychiatry. Morphological conceptions being dominant in medicine, it was found also that a number of terms and phrases are so commonly employed in medicine that their use has been compelled in psychiatry, although they embody conceptions and theories inconsistent with its dependence upon functional conceptions of mental pathology. The inquiry having led to the conclusion that the physiology of the life-process is the first recourse for psychiatry, in the search for explaining principles it becomes necessary to be emancipated from all preconceptions. The functional conceptions, being framed, and applied consistently with the facts of physiology and psychology, lead to a recognition of the developmental and genetic character of the functional modifications, and indicate their sources in physiological facts. A clearer idea is gained of the relation of conscious experiences to body states, and of the influence of the "somatic group of senses" in the relations of the conditions of the whole organism to the mental states. The dependence of all functional phenomena upon the processes of nutrition and metabolism for the maintenance of the nervous and mental mechanisms points to the fundamental importance of pathological physiology and chemistry. Physiological and psychological experiment in the immediate clinical examination of functional modifications shown in symptoms helps to determine the physiological sources of the contributing disorders in the whole body as well as the central nervous system.

The psychiatrist inclined to inquiry finds, in the pursuance of his practical work, that as a physician he must treat the whole body, and that a functional conception of mental diseases leads to treatment. Psychiatry belongs to general medicine and mental disease like bodily disease is not an entity nor an agency, but the result of normal function acting under abnormal conditions; the problem requires the investigation of the developmental and genetic character of functional modifications.

MURAL PAINTING

Photogravure from the original Plafond Painting by Michael Munkaczy.

In this fine composition the great painter, Munkaczy, has introduced the portraits of various great painters and sculptors. The section reproduced here is part of the painted ceiling of the Museum of Historical Art at Vienna.

SECTION H — SURGERY

SECTION H — SURGERY

(*Hall* 13, *September* 23, 10 *a. m.*)

CHAIRMAN: PROFESSOR CARL BECK, Post-Graduate Medical School, New York.
SPEAKER: DR. FREDERIC S. DENNIS, F.R.C.S., Cornell Medical College, New York City.
SECRETARY: DR. J. F. BINNIE, Kansas City, Mo.

THE HISTORY AND DEVELOPMENT OF SURGERY DURING THE PAST CENTURY

BY FREDERIC S. DENNIS

[**Frederic S. Dennis,** M.D., F.R.C.S. England, Professor of Clinical Surgery, Cornell University Medical College. **b.** Newark, New Jersey. A.B. Yale University, 1872; M.D. Bellevue Hospital Medical College, 1874; M.R.C.S. Royal College of Surgeons, 1877; F.R.C.S. *ibid.* 1899; Post-graduate, Universities of Heidelberg, Berlin, and Vienna, 1899. President of American Surgical Association, 1894; Attending Surgeon, Bellevue and Saint Vincent Hospitals; Consulting Surgeon, Montefiore Home and Saint Joseph Hospitals. Member of the Clinical Society of London; German Congress of Surgeons; American Medical Association; New York Surgical Society, and many others. **Author of** *System of Surgery;* **contributor to** American text-book of surgery.]

THE first word of the speaker on this occasion must be a personal one of respectful acknowledgment. To be invited by the administrative board to deliver an address upon any theme before this august Congress, composed as it is of many of the world's most distinguished men of science, is a distinction which any one might justly prize. But to be chosen as the orator upon a topic so important, far-reaching, and comprehensive as the history and development of surgery during the past century is an honor so exalted that while it pleasantly gratifies, it also most seriously appalls.

Permit me at the outset to record my profound and grateful appreciation of the high honor thus conferred, and at the same time to express the hesitation which I feel in attempting to handle so great a theme within the necessary limitations of the hour. It is obvious that the task is as fascinating as it is difficult. It is undertaken at the earnest solicitation of friends who have much stronger confidence than the speaker in his ability to narrate in a fitting way the triumphs of our great science.

To weigh the surgical events of a hundred years ago, and the motives which gave rise to them, requires us to summon to our thought, as far as possible all the circumstances of that period. Only when this retrospect is made, and the meager results then attained by surgery, are compared with its notable achievements in the present day, can the idea be fully grasped of how great, how wonderful, how grand, has been the progress during the past century. The advances which have been made in every department of human activity, the victories gained in every field, the innumerable inventions, the marvelous discoveries, the daring exploits carried forward to successful completion, the magnificent results secured along all scientific lines, are all discussed and celebrated in the meeting of this International Congress. But while the other sciences have indeed thrilling stories to relate, and can point with just pride to excellent deeds performed, the science of surgery stands out in bold relief and conspicuous grandeur, apart from and above the others, in that it deals directly with human life, that most precious of mortal possessions, often lending to it not only a helping but a saving hand. At the same time its story is so simple and yet so grand that the child and savant may alike participate in the pleasure which the wonderful narrative is fitted to convey.

Surgery as a science made no profound impression upon the world until about a century ago. But from that time to the present the almost miraculous works which it has wrought, increasingly marvelous with every passing year, have aroused astonishment and admiration in every quarter of the globe.

In order to appreciate what surgery has accomplished, it is necessary to refer briefly to its status prior to 1800. A little over a century ago surgery as a science had no existence. It had no definite or dignified position. It received no aid or support from reigning monarchs or kings. It was in the hands of charlatans and quacks and barbers, and it was practiced with some few exceptions by uneducated and irresponsible men. It was only in 1800 that surgery was divorced from the traditions of the past and was given a place among the sciences. It was in 1800 that the Royal College of Surgeons obtained its charter from Parliament, which had refused over and over again to grant it. So bitter was the opposition to granting a charter to the "Company of Surgeons" that Lord Thurlow is said to have proclaimed in the House of Lords that "there is no more science in surgery than in butchering." It was only by an appeal to King George the Third that this charter was finally obtained. In marked contrast to this attitude of Parliament was the scene enacted at the Centenary of the College of Surgeons, a few years ago. Here were assembled the foremost statesmen of England, and the leading scientists of the world, to do honor to the occasion. The King himself joined in the banquet as an honorary member of the Guild. During all these centuries prior to 1800, as has already been stated, surgery had no established place among the sciences. Medicine, on the other hand, had a well-defined and honorable status. It received abundant help and liberal support from kings and rulers. Thus it becomes evident how bitter the struggle has been for surgery to establish its claim to honorable and dignified recognition. Thus it becomes apparent that the difficulties to be overcome to establish that recognition were then insurmountable. This is not to be wondered at when pain in surgical operations, inability to control hemorrhage, and prevention of blood-poisoning, were the obstacles to the successful practice of the art. These evils retarded the growth of surgery. Their removal since 1800, and chiefly during the past quarter of a century, has cleared the way for the achievements of the present day. From Hippocrates, who was born 460 B. C., to 1800 A. D., surgery made little advance. It was practiced by illiterate men, with here and there a masterful mind groping in the dark for light. There were two great discoveries prior to 1800 that had an influence on the progress of surgery after that time, and without which surgery could never have become a recognized science. The first discovery refers to the circulation of the blood, which was made by Harvey in 1628, and the further discovery of the capillary system by Malpighi in 1661. The fearful dread of hemorrhage from an unknown source prevented any operations except those of dire necessity, which were generally performed through dead and gangrenous tissue. The second discovery refers to inflammation, the healing of wounds by blood-clot, and the ligation of the vessels in their continuity, by John Hunter, who was born in 1728. These two great discoveries prior to 1800, like the two great discoveries after 1800, viz., anesthesia and antiseptics, have enabled surgery to establish its just claim to recognition among the sciences. These four great discoveries, the circulation of the blood, the repair of wounds, anesthesia, and antiseptics, are the four corner-stones upon which a superstructure has been erected that has become a veritable temple of science, the dimensions of which eclipse in grandeur all other temples.

The progress has been greater during the past century than in all the preceding centuries since the beginning of the world. This progress which surgery has made is due, in great part, to the dissemination of medical literature, to the formation of medical libraries, to the organization of modern hospitals, to the equipment of scientific laboratories, to the foundation of medical schools, to the establishment of medical museums, to the organization of training-schools for nurses, and, finally, to the two transcendent discoveries — anesthesia and antiseptics. That medical literature has had much to do with the advance of surgery during the past century is evident when it is shown that at the beginning of the Revolutionary

War there was only one medical book, three reprints, and about 20 pamphlets by American authors, while to-day there is on the average one new book for each working day in the year, 300 journals, and 5000 original journal articles. American writers are publishing annually at least 500 medical volumes, to say nothing of the issuance of nearly 10,000 journal articles each year. In the department of surgery alone, during the two years of 1879-1880, there were written in America no less than 45 surgical books of importance and value, together with 1717 journal articles beside, and from this record of nearly a quarter of a century ago some idea can be gained of what surgical literature has accomplished at the present time.

That the foundation of medical libraries has had much to do with the progress of surgery becomes manifest when it is considered that a hundred years ago there were in this country only about 250 medical volumes, all told, while to-day there are nearly 160,000 volumes in the libraries of medical colleges alone, to say nothing of the large and general medical libraries throughout the country, without mentioning the thousands and thousands of volumes in the medical libraries in Europe.

That modern hospitals have had much to do with the advance of surgery is apparent when it is remembered that there were scarcely any hospitals a hundred years ago, while to-day they crowd nearly every city and town. This statement is emphasized by the fact that in New York and in Philadelphia there are four free beds to every 1000 of their respective populations; and by the further fact that any American city without adequate hospital accommodations is looked upon as in disgrace and behind the age; and, further, that the 433 hospitals in this country which maintain training-schools for nurses exceed in value $73,000,000, and their endowments exceed $18,000,000. These figures represent less than a fourth of hospital wealth, since many of the hospitals maintain no training-schools.

That the establishment of scientific laboratories has been a potent factor in surgical progress is proved by the fact that millions of dollars have been recently devoted to this purpose, and the work performed in these laboratories has had a tremendous influence upon the world. To Andrew Carnegie is due the credit of building the first purely scientific laboratory for medical and surgical research in this country; and from his example other like laboratories have been established in the land, until now America eclipses the world in the wealth and magnificence of its scientific institutions. The Laboratory of Hygiene in Philadelphia and the Caroline Brewer Croft Fund for the study of cancer at Harvard University are worthy of mention. Many well-equipped laboratories have been built in connection with large universities; while the magnificent gift of the Rockefeller Institute for Original Research affords another example of the influence which these establishments exercise in the development of medicine and surgery. In the Carnegie Institute there is a fund yielding over $300,000 per year to be expended on its work. In a conservative estimate the property investment in all kinds of medical institutions, such as hospitals, laboratories, medical colleges, health department bureaus, training-schools for nurses, etc., is three or four hundred millions of dollars, not to mention the endowment funds.

That the foundation of medical schools has had a great influence in the history and development of surgery becomes apparent when it is considered that about a hundred years ago there were only 200 medical men in practice in this country, while to-day there are over 100,000 workers in the field. A century ago our own country could boast of only two small medical schools, while now there are 154 medical schools, affording instruction to 26,821 students annually, many of whom will work in the chosen field of surgery; and nearly all of these medical schools are an integral part of some great university; $418,000,000 scarcely represents the value of the property belonging to medical schools, and $8,000,000 their endowment.

The recent munificent gift by Colonel Payne to Cornell University for the establishment of a medical department in New York City marks a most important epoch in the education of the physician and surgeon in the country. It is a fact worthy of honorable mention that the wealthy men of the present century have contributed most liberally to the science of medicine, as is obvious from a review of the recent different gifts and endowments amounting to many millions, especially during the past few years.

That the establishment of training-schools for nurses has had much to do with the progress of surgery is obvious when it is considered that about a quarter of a century ago there was not an American trained nurse, if any, in the United States. To-day there are about 11,000 pupils, and nearly 20,000 graduates. The inauguration of the first training-school for nurses in the United States at Bellevue Hospital in 1873 marks an important epoch in the history of modern surgery in this country. From the initial school at Bellevue others have been established throughout the country, and now every important hospital in the land has a competent corps of trained nurses as an essential feature of the modern hospital. The far-reaching and widespread influence of the Bellevue training-school, which was the first in this country to grant a diploma, cannot be over-estimated, as it relates to the improvement in the care of the sick, to the establishment of other training-schools, and to the opportunity offered to make possible the practice of surgery of the present century. The valuable services of Mrs. W. H. Osborn for nearly thirty consecutive years and the untiring labors of Mrs. W. P. Griffin, who has been its faithful president for nearly twenty-one years, entitles them to a high place of honor in the estimation of the medical profession. The progress of surgery in this country has been largely influenced by the help and aid which this department of philanthropy has offered to suffering humanity.

It is indeed a truth that without the Bellevue Training-School for Nurses, and the influences which have sprung from it, the surgery of the present century and notably of the last quarter of a century in America would not have been possible. The lady managers of the noble charity can feel a just pride in the silent and beneficent work which they have accomplished on behalf of suffering mankind, and can feel, moreover, that they have participated in the great work that marks a milestone in the progress of surgical science in the United States.

That medical museums have exerted an important influence is apparent from the fact that a century ago there were none in the land, while now there are many. Not a few of these are admirably equipped and appointed. They contain over 200,000 gross specimens. For their maintenance nearly $200,000 is expended annually, or one dollar each for the preservation of each specimen.

The history of surgery during the past century furnishes one of the most remarkable chapters in human affairs. It is obvious that life is the most important factor and element in the history of the race. Without life, of what avail is all else in the world? Surgery has to do with the saving of human life, and as such is the grandest and noblest of the sciences, and the most beneficent to mankind. A study of its development brings us face to face with the most startling and miraculous discoveries which have had an influence upon the health, the happiness, and the mortality of the race.

It is only necessary to remember that a little over a hundred years ago there were scenes enacted in the name of surgery which eclipsed in horror the frightful cruelty of the Spanish Inquisition, the untold miseries of the Bastile, the indescribable sufferings of the Black Hole of Calcutta, the excruciating pains of the Turkish bastinado, and the cruel massacre of the Huguenots. One shudders at the horrible cruelties which were perpetrated on withering mortals in the name of surgery. The records of suffering which have come down to us through the years of the century have no counterpart in the various experiences of modern life. Patients were held down upon the operating-table by brute force and were operated upon while in the full possession of their senses; they were heard to shriek and to cry out in heartrending screams for a discontinuation of their tortures; they were incised with red-hot knives, and they were compelled to have their wounds dipped in a caldron of seething tar to control hemorrhage.

Through God's infinite mercy in the progress of the century, all this is now changed. The patient falls asleep without a struggle; and when he awakens to consciousness the operation is finished. The convalescence is fever-free and painless; the mortality is reduced almost to zero in many cases, and the operation itself robbed of all its horrors. The evolution which surgery has made to effect such a wonderful change is one of the most fascinating studies in the world's history.

To dwell upon this in orderly manner is the purpose of the present discourse. In order to simplify as much as possible the comprehensive subject, it is necessary to divide it into four different parts, and to trace the rise, progress, and development of surgery in its triumphal march as it pertains to these four great events in history, during the past century.

1. The discovery and employment of anesthetics.
2. The discovery and practice of antiseptics.
3. The discovery and application of modern therapeutics and of new diagnostic aids.
4. The improvement of old and the discovery of new operations with their mortality.

1. *The Discovery and Employment of Anesthetics.* Among the important events in the history of mankind which have been far-reaching and beneficent in their influence, the discovery of anesthesia easily stands in the foremost ranks. What greater blessing has science ever conferred upon the human race? Other discoveries and inventions have indeed been revolutionary in their results for social advancement and comfort; but anesthesia outranks them all, in its combinations of kindness and power at a point of unutterable need. This wonderful boon to suffering humanity, now gratefully in use throughout the civilized world, comes from our own land — America. No other nation has presumed to lay the slightest claim to any priority in its discovery. Anesthesia with its world-wide blessings is confessedly American.

In 1844, Horace Wells, a dentist of Hartford, Conn., heard a lecture by Colton on nitrous oxid gas. In illustration of the lecture the gas was administered to a person in the audience. The man fell to the floor; but was insensible of his fall, confessing afterward that he was absolutely unconscious. This episode caused Wells to think that perhaps the gas could be utilized in dentistry for the painless extraction of teeth. With a true courage of his convictions he tried the experiment upon himself, inhaling the gas, and having one of his own teeth extracted by his assistant. When a few moments afterward, he returned to consciousness, he cried out in his enthusiasm, "a new era has dawned upon the world, I did not feel it more than a pin-prick," and Horace Wells was a greater prophet than ever he dreamed himself to be in the moment of wild excitement.

In 1844, William Morton, a Boston dentist, heard that sulfuric ether could be inhaled in small quantities, and that it produced a certain degree of unconsciousness. Like Wells, Morton immediately tried the experiment upon himself, a daring thing to do. After inhaling the ether he became insensible for eight minutes. The moment he came to himself, the thought flashed through his mind that in ether was a vapor which would produce insensibility for a longer period than gas, and that here was an anesthetic peculiarly suitable for surgical work. Accordingly, he sought his opportunity. It came on October 16, 1846, a red-letter day in the history of surgery, not only in America, but throughout the world. That day Morton administered ether to a patient in the Massachusetts General Hospital, in Boston, who was to be operated upon by Warren for the removal of a vascular tumor. Under the influence of ether the patient remained unconscious during the operation, which was highly successful. To be sure Crawford W. Long had administered ether prior to this time, but Long did not quite trust the evidence of his own experiment, and feared that his success might be due to an incidental hypnotic influence. The work of Jackson should also be mentioned, since as a chemist he made ether; but it was Morton who really proclaimed the discovery of anesthesia in an emphatic way, so as to arrest universal attention, and introduce a new epoch in surgical science.

November, 1847, was another red-letter day in the progress of surgery, for on that day Simpson, the famous Scotchman, made announcement of chloroform as a valuable anesthetic.

One of the most memorable nights in the history of the world was when Simpson resolved to try personally the inhalation of chloroform. Sitting with his friends, Duncan and Keith, around a supper-table, he proposed a trial of the experiment. The three men, without the slightest adequate knowledge of what the result would be, inhaled the vapor. It was a brave, hazardous thing to do; but they did it. Almost instantly their conversation sparkled with unwonted scintillations of wit and humor; but it suddenly ceased, and a death-like silence reigned in the room. In a few moments the sound of falling bodies might have been heard; and then again all was silent. Simpson was the first to recover consciousness. He says that when he did so, he heard himself saying: "That is good." Then he saw Duncan lying on the floor, sound asleep and snoring; while Keith was struggling to regain the chair from which he had fallen when the chloroform did its work.

That was an historic scene, fraught with inestimable value to mankind. Here were three noble men, brave heroes, every one of them, experimenting at the conscious risk of their own lives, with a vapor respecting whose fatal qualities they knew not, in the hope of discovering a way by which poor suffering humanity might be spared from pain. They took the chance of sacrificing their own lives if necessary, for the good of mankind. Such acts of patient research, weary waiting, unselfishness, bravery, and heroism belong only to a profession in which saving of human life at the risk of losing one's own life is undertaken.

It appears that Simpson's mind had long worked on the great and perplexing problem. His daughter tells us that "very early in his student days he had so sickened at the suffering he witnessed in the operating-theater that he had shrunk from the scene, decided to abandon his medical studies and seek his way in the paths of law." This, however, he did not do. On the contrary he resolved "to fight a good fight" in the field upon which he had already entered, and he did, getting to himself an undying fame thereby, and conferring an immeasurable benefit upon mankind to the end of time.

Before leaving this part of our subject, it seems pertinent to call the attention of the enemies of vivisection to the splendid heroism and unselfishness which Wells, Morton, and Simpson displayed in making these hazardous experiments upon themselves, and not upon lower animals. This world would be far better off if these enemies to the true progress of surgery would take this noble object-lesson to heart, and cease their senseless tirade against vivisection, which has been as absolutely accessory to science as its benefits have been great. The only object and aim of vivisection is to save man from suffering, misery, and death. Shakespeare's thought that "it is sometimes necessary to be cruel in order to be kind" is true in this connection.

The topic of anesthesia must not be dismissed without a reference to Koller's discovery of local anesthesia by cocain, especially in ophthalmic surgery. The use of the spinal canal for medication, of which the injection of cocain for anesthesia is one of the administrations in vogue, was suggested by Corning in 1884. This particular form and method of anesthesia has been a contribution to surgery within the past quarter of a century, and has met the needs of a class of cases to which general anesthesia could not be applied.

As to the mortality of anesthetics, Poncet concludes that chloroform is more dangerous than ether, since Juillard's and Gurlt's statistics show one death in from 2000 to 3000 administrations of chloroform, and one death in from 13,000 to 14,000 of ether, while in nitrous oxid gas there are practically no deaths.

The influence of the introduction of anesthetics upon the progress of surgery can be best illustrated by a reference to the statistics of operations recorded in the Massachusetts General Hospital. Halsted has given the figures for 10 years before and 10 years after the discovery of anesthesia, which I quote. During the 10 years prior to the employment of anesthetics, there were only 385 operations performed in the Massachusetts General Hospital, or about 38 annually, or about 3 each month, or less than 1 a week. In the 10 years after the use of anesthetics began, and before the discovery of antiseptics, there were 1893 operations, or say 189 annually, or about 15 every month, or nearly 4 each week. If now the number of operations in the same hospital during the past 10 years is considered, it is found that they amount to 24,270, or about 2427 annually, 262 every month, and about 50 each week, while of those performed in the year of 1903, they number no less than 3109, or about 250 each month, or about 65 each week. What a tremendous advance upon the less than one operation each week of about half a century ago to the 65 each week at the present time in one hospital alone. It must be said, however, that this remarkable increase is largely due to the introduction of antiseptics, as well as anesthetics, in surgical practice. In other words, Hoffman has shown that the increase in surgical operations during the past half-century has been more than six times as great as the increase in hospital patients as determined by the Massachusetts General Hospital. So we are led to the second chief topic of this address.

2. *The Discovery and Practice of Antiseptics equal in Importance that of Anesthetics, and contribute almost as largely to the Progress and Development of Surgery during the Past Century.* This discovery, unlike that of anesthesia, belongs exclusively to no one nation. Pasteur, in France, discovered that putrefaction is due to the presence of bacteria in the air. Lister, in Scotland, applied the discovery to surgery. In Germany and in the United States a yet further application of the technic was made. Antiseptics, therefore, have been an evolution in which all well-progressed countries, notably Great Britain, have taken a part. Lord Lister's discovery will always stand as one of the great milestones in the advance of surgical science.

There are certain remarkable facts connected with the early surgery of this country which clearly foreshadowed the introduction of antiseptics. Absolute cleanliness was a characteristic feature of Mott's surgery. His personal toilet and the cleansing of every instrument before use indicated that he recognized perfect cleanliness as a *sine qua non* to surgical success; also the employment of animal ligatures in this country anticipated their general adoption as an essential part of antiseptic technic. Dorsey, as early as 1844, successfully ligatured large vessels with buckskin and catgut.

Hartshorne used parchment and Jameson proposed ligature from deerskin. All these factors, which now are recognized as an essential part of antiseptic surgery, were marked steps toward the perfect aseptic technic of to-day.

The general subject of antiseptics cannot be passed over without a just and generous recognition of Lord Lister's work. It is simply right to say that to him belongs the exclusive honor of having discovered antiseptic surgery. While at Glasgow, in his early professional life, Lord Lister became impressed with "the evils of putrefaction in surgery." What appalled him in his clinical observations was the difference of healing between a simple and compound fracture. In a compound fracture there was communication between the seat of fracture and the external air. This condition gave rise to suppuration, blood-poisoning, and death. In a simple fracture there was no communication between the seat of fracture and the external air, and the wound healed speedily without suppuration, blood-poisoning, or death. This striking behavior in the action of wounds léd Lister to the discovery which has made his work imperishable, and has given an earthly immortality to his name. Mr. Lister believed that the blood in the wound underwent putrefaction in the same way as Pasteur had demonstrated that meat decomposed through exposure to the air. Lister's first endeavor was to overcome the evil by scrupulous cleanliness, just as Mott had done. But he quickly found that this method was inadequate to meet the need. Studying the subject, he immediately realized that Pasteur's theory was correct; that putrefaction was a fermentation produced by bacteria in the air; that these microörganisms could not develop *de novo*, in the putrefying substances; and that there was no such thing as spontaneous generation of bacteria. He also saw that when the bacteria in the air could be prevented from entering the wound, the wound would not suppurate nor give rise to blood-poisoning. He then asked himself the question, how can these bacteria be destroyed, or how can their fatal entrance into a wound be prevented? In other words, how could we kill the bacteria and yet not harm the patient?

This was the problem and proposition. Its solution is antiseptic surgery. Lister had heard of carbolic acid as a deodorizer. As such he applied it, undiluted, to a compound fracture, with repeated renewals. Watching with intense interest the application, he was overjoyed to see that suppuration was almost entirely prevented and so all fear of blood-poisoning and death removed.

This was, practically, the discovery of antiseptics. A method for preventing putrefaction was found, and in consequence aseptic healing by gradual evolution and by modern improvements followed. No one can measure the vast influence which this wonderful discovery has had upon the human race. It has eliminated local pain in a wound, it has prevented general fever, it has made possible many new life-saving operations, it has saved millions of lives.

The influence of antiseptics upon the increase of surgical operations, and the decrease of mortality attending them, is difficult to estimate. Suffice it to say, by way of illustration, that in the Boston City Hospital prior to the introduction of antiseptics there were, in 1878, according to Halsted's statement, only 132 operations performed, while in the same hospital, in 1903, there were 2719. In the New York Hospital, in 1878, there were 142 operations, in 1903, there were 1680. How different and justly so the prevailing idea of the day as regards the operative part of surgery. Prior to the past century, operations were looked upon as a tacit confession of failure, and such they commonly were. To-day, they are properly recognized as the grand triumph of a new science. These facts tell the story of the progress of surgery more forcibly and eloquently than could be done by any spoken discourse, no matter how carefully prepared.

3. *The Discovery and Practice of Modern and Surgical Therapeutics and of New Diagnostic Aids.* This part of our subject embraces all the non-operative methods of treatment of surgical affections which have been devised during the past century. It is obvious that within the limits of this address mere mention only can be made of the various remedial agencies and the general results which have been obtained by their application.

The Röntgen rays were discovered about 1896, and the civilized world was startled by a discovery which ranks after anesthetics and antiseptics as one of the greatest advances in the science of surgery. Röntgen demonstrated that the Röntgen rays would pass through the human body and throw a shadow picture on a photographic plate. In other words, that the rays had the power to pass through substances which were opaque to ordinary rays of light. Bullets can be seen and located in the body, and bones can be distinctly outlined, because they are denser than the soft tissues. Fractures and diseases of the bones, dislocations and diseases of joints, as well as foreign bodies in the economy, can be observed. Tuberculous processes in the lungs can be distinguished, and the heart can be seen actually pulsating. Gall-stones can be made out in the gall-bladder, and calculi can be detected in the pelvis of the kidney and in the urinary bladder. Sarcoma, myelitis, syphilitic osteitis, bone abscess, periosteal and central origin of bone tumors can be diagnosticated. Carcinoma, tuberculosis, osteoarthritis, osteoporosis can be made out with distinctness. Brain tumors, notably gumma, Hodgkin's disease, aneurism of the large vessels, and glandular enlargements and growths in the mediastinum can be demonstrated.

The Röntgen rays have also been used with a view to the cure of certain malignant diseases, notably cancer of the skin and sarcoma, especially when the disease cannot be treated by ordinary means. It does not appear to have been of any special value in other forms of cancer located in the organs of the body. The Röntgen ray has also been employed as a depilatory, also to bring about atrophy of the glands of the skin and to relieve pain. The Röntgen ray also is used to cure pseudoleukemia and splenomedullary leukemia, rodent ulcer, lupus vulgaris, and chronic eczema.

Great credit belongs to our distinguished chairman for the magnificent work which he has performed in the application of the Röntgen ray to surgery, and his writings upon this subject are worthy of close study.

The *Finsen light* is a discovery which was made about 1897, by means of which certain forms of cutaneous disease of an infective origin, notably lupus, have been cured. This result is accomplished by means of a light which can be employed without accompanying heat, and which causes an inflammation of moderate intensity upon the skin. Sunlight fails to destroy bacteria, owing to the presence of heat, while the Finsen light, deprived of heat, effects a cure.

In 1878, Blunt and Downes proved the efficacy of chemic rays of light to kill bacteria. Finsen demonstrated that the action of light was increased if it be applied through rock-crystal lenses, and the heat absorbed by passing it through a violet-colored liquid and water, while the part of the body to be treated is made anemic by pressure. Finsen apparatus increased the efficacy of the violet or chemic rays, and absorbed red or heat rays. The effect of light upon bacteria is slow in its operation, but its rapidity is increased by concentration, by means of mirrors or by lenses. The heat-rays, such as ultra-red, red, orange, or yellow, must be eliminated, as they burn the tissues, while the blue or violet rays destroy the bacteria. The arc electric light comes next, and is now often used because it can be obtained at all times. The incandescent light is of no value, owing to the fact that it possesses too few chemic rays. The electric light requires a special apparatus for its use, since its rays are divergent and not parallel, as is the case in the sun's rays. Professor Pupin says that the time is not far distant when a new method of producing light of short wave-length will be perfected, which will be far more powerful than the Finsen light. The shortcomings of the present method of producing light of great actinic power consist principally in the absorption of this light by the glass of the vacuum tubes in which it is produced. Within the last year a method has been discovered of fusing quartz, and blowing it out by means of the oxyhydrogen flame into bulbs, which are used for electric vacuum tubes. Quartz, as is well known, absorbs light of short wave-length to a very slight extent, and it is the light of short wave-length which is employed at the present time for therapeutic purposes. When this discovery is applied to surgery, the field of usefulness of light as a remedial agent will be greatly enhanced, and without doubt many new diseases will be relieved that the present Finsen light fails to cure. The results of treatment of lupus by the Finsen light are interesting. In 456 cases in which the treatment had been completed at the end of 1900, no fewer than 130 are known to be free from recurrence for from one to five years. In the rest of the cases the period of cure is too short to establish any reliable data. In 44 cases of lupus erythematosus, 14 were reported cured and 15 improved. In 49 cases of alopecia areata, 30 were reported cured. In 24 cases of rodent ulcer and cancroid, with 11 favorable results. In 25 cases of acne vulgaris, 13 were cured. These statements give an approximate idea of what has been accomplished in a short time by Finsen light, and, without doubt, improvement in the technic will result in even a greater number of percentages of cure.

Radium is a new element which was discovered in 1899 by Madame and M. Curie. The term "radium" is derived from the Latin word *radius*, meaning a ray. At the present time there is great interest in the question of the therapeutic use of this metal, but sufficient time has not elapsed to determine its value.

Radium is a new therapeutic agent which has recently been used in surgery, and furnishes a new illustration of the development of the science. Radium as a therapeutic possibility is little understood, but about which much has been written. The public press has been flooded with sensational articles about radium, while the medical press has been conspicuous for the meager accounts of its therapeutic uses.

The action of radium depends upon its "spontaneous source of energy" upon living tissues. The action of radium upon the tissues is very similar to the Röntgen rays, and its use is indicated in those cases in which the Röntgen ray is applicable. Radium as a therapeutic agent depends upon its radiations, which are of three kinds, and have been designated by the terms Alpha rays, Beta rays, and Gamma rays. The Alpha rays consist of a current of electric charge that contains an amount of energy far greater than the Beta rays or the Gamma rays. The velocity of the Alpha rays is said to be 20,000 miles per second. Ninety-nine per cent of the energy of radium is in the Alpha rays. The Beta rays consist of a negatively charged stream of particles very similar to the cathode. The Gamma rays travel with tremendous velocity and are similar to the Röntgen ray from a hard tube. The Alpha rays have very slight actinic properties, while the Beta and Röntgen rays are highly actinic, and are therefore the rays used in therapeutics. Beta rays do not penetrate the tissues deeper than half an inch, while the Röntgen rays from the pure radium pass through the body. Radium gives off heat and a gas called helium, but these properties have no influence in the therapeutic action of radium. Radium destroys bacteria and affects the metabolism of cells and is used in the treatment of certain skin affections, notably lupus, keloid, nevi, rodent ulcer, epithelioma, carcinoma, and sarcoma. The action is similar to the Röntgen rays, but the chief advantage of radium consists in a precise estimate of the dosage, while the Röntgen ray, on the other hand, is a more powerful energy, but it is difficult to estimate its exact strength.

Electricity has had great influence in the development of surgery during the past century. It has been employed in many ways, both as a diagnostic aid and as a means of cure. The electric light is used as a means of diagnosis to explore the hidden parts of the body such as the throat, larynx, esophagus, and stomach, also the bladder and the intestinal canal. Perhaps one of the most useful purposes to which electricity has been employed in a diagnostic way is illustated by the cystoscope by means of which the interior of the bladder can be explored with a view of determining the exact nature of the lesion, the shape and anatomic relations of a growth, or the presence of a foreign body in the hollow and heretofore impenetrable viscus. The stomach also has been explored with a view to determine the nature of the lesion. It is also used to test the contractility of muscles which should respond quickly to the faradic current if the nerve is diseased. In this way the surgeon can diagnosticate functional or organic disease of the nerve by the behavior of the muscles when the electric current is applied. The electric current is used in surgery as a curative means in the removal of small malignant growths and nevi, to arrest primary hemorrhage in places when the ligature is inapplicable, or secondary hemorrhage where compression is not admissible. In the form of an *écraseur*, electricity is used to remove pedunculated tumors, to cauterize long sinuses, to arrest suppuration in the eyeball, to sterilize the pedicle after appendectomy, ovariotomy, or hysterectomy, to cause coagulation of blood in the treatment of aneurism, to overcome obstruction in the eustachian tube, to find bullets imbedded in the human body, by a probe which was invented by Girdner of New York, to stimulate muscles and nerves, to improve the circulation of the blood, and even to relieve severe pain.

Serum therapy is a newly discovered method for the treatment of certain surgical diseases, among which may be mentioned hydrophobia, tetanus, acute phlegmonous inflammations, anthrax, and other infectious processes. The history and development of surgery during the last quarter of a century would be incomplete without a reference to the inoculation method to prevent certain surgical diseases. The principle involved in this system is the one enunciated by Pasteur, to whom the world owes an everlasting debt of gratitude.

In 1880, Pasteur announced to the French Academy of Science that he had discovered a method of inoculation, by means of which he could reduce the virulence of a disease caused by a special germ. An attenuated virus of the germ-disease was inoculated into the system of a susceptible animal, and this infection would give rise to only a mild attack of the disease. The attenuation of the virus, as Pasteur termed it, was accomplished by cultivation of the special germ in certain mediums exposed to the air. His research up to this time was limited to chicken-cholera; but he announced that in the future he believed that the great principle of inoculation would extend to other diseases. In 1881 he proved to the world the correctness of this view by announcing his cure of anthrax, that fatal malady affecting sheep and cattle. The world was skeptical of his discovery, and the president of the Agricultural Society of France urged Pasteur to make a public test of his cure. To this proposition Pasteur, in the true spirit of scientific faith, assented, because he was fully convinced of the truth of his theory. Fifty sheep were supplied by the president of the Agricultural Society for the test. To this flock Pasteur requested that 10 cattle be added and 2 goats be substituted for 2 sheep, with the understanding that failure in his experiment with cattle and goats must not invalidate the test, since he had never carried on experiments with cattle or goats. The acceptance of this challenge by Pasteur was a brave act; because he knew if he failed in this public experiment the world would denounce and deride him. The inoculations of the attenuated virus of anthrax were then made on 24 sheep, one goat, and five cattle, at certain intervals upon three successive occasions. After a proper time had elapsed the 60 animals were inoculated with a culture of the anthrax microbe. Forty-eight hours after this injection of the full-strength virus into all the animals, the public gathered to witness the success or failure of this most wonderful experiment in the scientific world. The sight that the eyes of the vast crowd beheld beggars description. In the paddock were seen dead or moribund every animal that had not been previously inoculated with the attenuated virus. In this same paddock were seen the remaining animals that were inoculated with the attenuated virus walking about apparently in perfect health. This paddock formed a veritable arena in which was witnessed the greatest battle that science has ever fought. The victory was complete, unequivocal, and overwhelming. This successful experiment established a new epoch, and this new principle was soon applied to certain human diseases.

In 1885 Pasteur proved the value of this method in the treatment of hydrophobia. In this latter disease the virus of rabies was inoculated into guinea-pigs or rabbits, and an attenuated virus was made from the spinal cord of these inoculated animals. The mortality of hydrophobia by Pasteur's treatment, by Celli, of Rome, has been only 5 %, since 1899, at which time the institute was built and organized, and during these four years 2000 patients have been treated with the serum.

The value of serum therapy is shown by a reference to the work of the lamented Walter Reed, of the United States Army, who discovered a treatment for yellow fever, a disease which destroyed over 80,000 persons in this country during the past century. To-day this scourge has been wiped from the face of the earth. The bubonic plague, the most frightful disease that could visit a country, created panics among the people in former years; but now, owing to the efficacy of serum therapy, its entrance into this country creates only a passing comment. Even in New York the disease was observed at quarantine, and was stamped out immediately. Thompson predicts before long that the bubonic plague, which is now practically confined to the valley of the Euphrates, will be annihilated from even that locality, as well as cholera from the valley of the Ganges. Haffkine's serum for the treatment of this bubonic plague reduced the susceptibility of those exposed to the infection 75 %, and the mortality by 90 %.

Gilman Thompson says that "thirty years of bacteriology in all of its applications have done more for mankind than all the medical research that has preceded. In an estimate made by Alfred Russell Wallace of 25 discoveries of world-wide importance made during the nineteenth century, a fifth were contributed by medical science, and all but one of these were made during the last half of the century. Two more have been greatly influenced by medical science, viz., the theory of the antiquity of man and the doctrine of organic evolution. Yet we have not wholly emerged from the shadows of the Middle Ages, for have we not still among us those who fain would abolish such experiments as have made possible discoveries like those of vaccine, antitoxin, and antihydrophobic inoculations, even as there are those in Persia who would mob physicians seeking to check the spread of cholera?"

Tetanus is a surgical disease which baffled the skill of physicians for centuries. Recently it has been treated with very encouraging results by means of antitoxin. This method of serum therapy, together with the application of antiseptic surgery, has yielded results that offer a striking illustration of the onward march of surgery. In olden times the mortality in tetanus, according to Lambert was 80 % for acute cases, 40 % for chronic cases, and 60 % as an average for all cases. The mortality in tetanus, treated by antitoxin and by antiseptic surgery, was about 61 % for acute cases, and 5 % for chronic cases, and 30 % for all cases.

From these statistics it is evident that antitoxin has reduced the mortality half, and if the antitoxin were properly used, the mortality would be much less than half. The reasons why antitoxin has no better statistics at the present time are because the antitoxin has not been pure or long enough continued, or not in sufficient doses, or too late in its administration. If properly used, the reduction in mortality would be striking, and from now on the results will be entirely different. Antitoxin has its widest field of usefulness as an immunizing agent. All surgeons agree that it would not be justifiable to immunize a patient on the vague supposition that tetanus might develop. The use of the antitoxin as a prophylactic measure is consequently limited to those cases where the wound has been inflicted in such a manner as to allow garden-earth, plaster from walls, or manured soil to come in contact with it, or where the traumatism has been caused by a rusty nail upon which the bacilli are discovered, or in a given locality where tetanus is prevalent, or where the wound is a lacerated one with entrance of foreign bodies into it. In these cases Murphy states that the injection of antitoxin has reduced the mortality 50 %.

Bazy, a French surgeon, had four fatal cases of tetanus in his practice in one year, and subsequently began injecting 20 cc. of serum into all patients who suffered from lacerated wounds, into which extraneous matter had of necessity entered. Since he adopted this practice, tetanus has not followed in those cases in which a strong probability existed that this dreaded disease might develop. Lambert mentions that Nocard, in veterinary surgery, immunized 375 animals, and in no single case did tetanus develop, while he had 55 cases of the disease in non-immunized animals in the same environment. Antitoxin does not affect in any way the life of the bacilli of tetanus, or the spores. Both the bacilli and their spores, when they penetrate the tissues by a wound, live for days and weeks. In these cases, when antitoxin is given for the purpose of preventing the symptoms which would be caused by the toxins during the first few days, it will destroy the action of the toxins. If, however, some of the spores remain quiescent, they may only develop into bacilli at a time when the antitoxin has been eliminated, and if they then develop into bacilli the toxins produced will be absorbed, and cause symptoms just as if they had received no immunization dose of antitoxin. For this reason, the immunizing dose should be repeated after the first week, and even after the third week.

Antitoxin as a remedy during the progress of the disease has an important influence upon tetanus; but not to the same extent as when employed for immunizing purposes. Welch believes that the longer the period of incubation, the better will be the results from the use of antitoxin, and that this remedy is of little value with a short incubation period, that is, less than seven days. When antitoxin is used under these circumstances, it should be continued long after the symptoms of tetanus have subsided. Lambert has also called attention to a most important point in the treatment of tetanus, and that is, the great care the surgeon should exercise after all symptoms have disappeared. For example, absolute quiet should be insisted upon long after the patient has become convalescent, since he knows of five deaths recently in New York City where the patients were awakened suddenly out of a sound sleep, and a convulsion was brought on from which the patients died.

Antiseptic surgery plays an important rôle in the treatment of tetanus, since it has been shown that in the majority of cases of tetanus the infection proceeds from the development of the spores rather than from the bacilli. It has also been demonstrated that the spores develop better under special circumstances of a mixed infection, and, therefore, all tetanus wounds should be made aseptic in order to destroy the microbes of suppuration, notably the streptococci and the staphylococci. It often happens that the wound is situated on an extremity, notably on the finger or toe, and the question arises as to the propriety of amputation of the affected part. This operation is of no avail unless the sacrifice is made immediately after the infliction of the injury, but it is indicated if the wound cannot be thoroughly disinfected. It is better to live without a finger or toe, or even a leg, than to run the risk of tetanus with its attendant suffering, which leads in the acute cases so often to death. The small punctured wounds, which may seem insignificant, should be incised deeply, thoroughly cleansed, and then properly drained. The toxins of tetanus are chiefly eliminated by diuresis. To best utilize this channel of elimination the imbibition of large quantities of fluid is indicated. The saliva has also been said to be a channel of elimination. The function of the skin has not been proved to be of any avail in eliminating the poison. The employment of anodynes forms also a prominent part of the treatment. This step, therefore, should not be overlooked, since it is clearly proved that much suffering can be relieved by certain drugs. Among the drugs that are found to be most useful are chloroform, morphine, chloral, bromides, physostigmin, antimony, and nitrate of amyl. Chloroform is a most valuable remedy, because it relieves the intense suffering and diminishes the intensity of the spasm and also prevents suffocation. This agent must be used with every precaution and with every stimulant present, and ready for immediate use. Statistics show that when chloroform was employed in the treatment of tetanus, the mortality was 10 per cent less than in the cases when the drug was not employed.

Thus it is evident that the use of antitoxin, the employment of antiseptic surgery, the administration of certain anodynes and the enforcement of quiet to avoid reflex disturbances, comprise a plan of treatment which will offer brilliant results in the cure of this terrible malady. The success of this treatment in tetanus alone is a monument of the progress which surgery has made during the past quarter of a century.

The antitoxin treatment of diphtheria affords the most forcible illustration of the value of serum therapy in the treatment of infectious diseases. This disease does not, strictly speaking, belong exclusively to surgery; but it affords an opportunity to show the results of the use of antitoxin, and it often happens that the disease may require surgery for its relief. From the statistics of the Health Board of New York City prior to January 1, 1895, the mortality was as high as 64%, and in 1902, as a result of the use of antitoxin, mortality was reduced to 9.5%. From a period of 5 years, from 1888 to 1894, the mortality was from 64% to 44%, and the following 4 years, from 1895 to 1898, the mortality dropped to 12%. In 1902 the mortality was reduced to 10.9 %. In another series the cases were also not selected. They were collected from hospitals, asylums, private residences, and many of them were moribund at the time of the use of the antitoxin, and the mortality was less than 8 %, as contrasted with 64% to 44% 20 years ago, or before antitoxin was employed. In 1903 the improvement was still greater, since in 1208 cases of diphtheria only 72 died, thus giving a mortality of only 5.9 %. If the 26 moribund cases were deducted, the mortality is only 3.8%. There remains no longer any doubt as to the value of serum therapy in this disease, and if these results can be taken as prophetic of the result of serum therapy in other infective diseases a new era has dawned upon the civilized world. Billings has called attention to one fact, and that is the necessity of the early administration of the antitoxin, since in 1702 cases injected on the first day, only 85 patients died including the moribund cases; the mortality was only 4.9%. Finally, in 1610 cases collected from 12 physicians in private practice, and not including the moribund cases seen in consultation, there were 24 deaths, or a mortality of only 1.5%. An antitoxin has been made by Calmette, who worked in the Pasteur Institute, to prevent death after the bites of venomous serpents. This antitoxin has already afforded immunity to thousands of persons who had been poisoned by the bite of venomous reptiles in India and Australia.

The antitoxin treatment of snake-bite was discovered by Vital, of Brazil. He made some extensive experiments with antitoxin at the institute over which he had charge. This serum was better than the control tests with Calmette's anti-venom serum. Vital called the serum anti-ophidic, and he reported 21 cases of bite of venomous reptiles with recovery, without any appreciable clinical symptoms. The strength of this anti-ophidic serum is shown by the fact that even a fraction of a milligram of the snake-venom causes severe symptoms to appear when injected into lower animals. In three of the 21 cases, the symptoms appeared almost immediately after the bite of the snake, and were most pronounced in type. In these three cases, however, 20 cc. to 60 cc. of the anti-ophidic was injected and recovery took place, notwithstanding two hours had elapsed in one case, and three hours in another case. Vital has also prepared a special serum for the bite of rattlesnakes.

In India, 22,000 persons and 60,000 cattle die each year from the bites of the poisonous ophidia. Many of these deaths can now be prevented by inoculation of the anti-venene. In tuberculosis the mortality has been reduced 50%. Koch's wonderful discovery is an enduring monument to his greatness. In Germany alone 90,000 persons die annually from tuberculosis. This gives us an idea of the far-reaching influence of Koch's marvelous discovery.

Blood analysis has had much to do with the development of surgery, and affords a most valuable diagnostic aid. Without this contribution from the science of hematology the development of surgery would never have reached its present state. This is not the place to enter upon any discussion of blood analysis except as it pertains to surgical diagnosis, by means of which the broad field of operative surgery has been enlarged. In speaking of blood analysis a reference only will be made to the influence it has upon operative surgery. Blood analysis makes certain the diagnosis in some surgical diseases, it aids in the diagnosis of other diseases, and it helps to diagnosticate a condition, where from unconsciousness, inability to speak, insanity, or malingering, a history is unattainable. The chief points to ascertain are the number of erythrocytes, the leukocytes, the ratio of one to the other, the number of blood plaques, and the ratio to each other, the size, form, and contents of the blood-cells, the amount of hemoglobin and of fibrin, the specific gravity of the blood, and bacteria contained in it. The erythrocytes or red blood globules normally exist in the blood in the proportion of about 5,500,000 in a cubic millimeter. The term oligocythemia indicates a deficiency in the number of red blood globules, or a diminution of their relative proportion. The term poikilocytosis indicates an irregularity in the shape and size of the globules, and an increase in the red blood globules is called polycythemia. Now oligocythemia is observed in hemorrhages, anemia, etc. Polycythemia is observed in cases, where there is a loss of fluid from the blood as in cholera, severe diarrhea, etc. The leukocytes or white blood globules normally exist in the blood in the proportion of about 7500 in a cubic millimeter. An increase of 1500 or more in the number of the white cells indicates a condition known as leukocytosis.

Now, a normal leukocytosis is observed in health after meals, during pregnancy, following violent exercise, a cold bath, and massage. An abnormal leukocytosis is observed in such diseases as erysipelas, osteomyelitis, suppuration, malignant tumors, and in pneumonia. The term leukemia indicates a permanent leukocytosis. In the differential diagnosis of surgical affections, blood analysis is of great assistance. For example, in shock from hemorrhage there is oligocythemia. In shock from concussion or compression of the brain, there is no decrease in red blood cells. In appendicitis and pus tubes, there is a leukocytosis, while in floating kidney, ovarian neuralgia, gall-stones, renal and intestinal colic, it is absent.

In meningitis, in cerebral abscess and cerebral hemorrhage, there is leukocytosis, while in other intracranial lesions it is absent, In all forms of sepsis, leukocytosis is present. Blood plaques normally exist in the blood in the proportion of 200,000 cm. to 500,000 cm. In disease, the plaques are increased.

Hemoglobin normally exists in the blood in about 90%, and below 20% is the minimum in life. The relation of hemoglobin to the erythrocytes and the rapidity with which it regenerates after injuries, surgical operations collapse, and hemorrhages, enables the surgeon to determine the prognosis. Syphilis and cancer retard the regeneration of hemoglobin, while tuberculosis, curious to state, increases the regeneration. In operation for removal of cancer, for example, the amount and rapidity of regeneration of the hemoglobin enables the surgeon to determine whether complete removal of the malignant tumor has been accomplished, and whether the rapidity is sufficient to justify the conclusion that perfect health can be reinstated.

4. *The Improvement of Old and the Discovery of New Operations with their Mortality.* It is obvious that a consideration of this part of the subject can only embrace a cursory review of the field of operative surgery. No attempt will be made to describe in detail an operative procedure. A mere reference to the improvements in old operations and the discovery of new operations will be made as affording tangible evidence of what surgery has accomplished for mankind. The operations that have been discovered and performed within the past 100 years will be mentioned, and an endeavor will be made to show to what extent the science of surgery has been a benefaction to the human race. In order to demonstrate this proposition, it is necessary to record the date of the first performance

of each prominent operation, and then to show what result has been accomplished since its introduction. In this way an idea can be obtained of the value of each great operation, and the advance which each has made toward saving life. A review of this kind naturally is devoid of popular interest, but at the same time these important factors are worthy of record and study. In this way only can the true progress of surgery be measured, since the operations performed prior to the past century are insignificant and unimportant. It is only by a study of the operations of the past century that the magnitude and usefulness of modern surgery become impressive and apparent. If what has been accomplished during the nineteenth century be taken from the sum total of knowledge of surgery, nothing will be left to entitle surgery to a recognition among the sciences. The work accomplished with the century, however, as a study entitles surgery to a prominent place among the sciences.

The important operations will be considered in the following order: Those belonging to the cranial, thoracic, and abdominal cavities, and finally those of a miscellaneous nature.

External to the cranial cavity, the operation for the cure of racemose arterial angioma, aneurisms of the scalp, sinus pericranii, dermoid cysts, sarcoma, and carcinoma, are among the recent operations that indicate the extension of surgery in this department. The improvement in the technic of the operation for compound fractures of the skull, fractures of the base, encephalocele, and within the cranial cavity, the operations for the relief of hydrocephalus, compression of the brain, ligation of the middle meningeal artery, are worthy of mention, as denoting the progress which surgery has made within recent years. Abscess of the brain has been recently treated with success. Delvoie cites 21 cases of trephining for acute cortical abscess, with 15 recoveries, and 33 operations for chronic deep-seated abscess, with 19 recoveries. In cerebral abscesses secondary to otitis media, Ropke reports 142 cases, 59 of which recovered, and 40% were permanently cured. Frontal abscesses of nasal origin have been operated upon with brilliant success. This life-saving operation which has resulted in cure, until recently hopeless, indicates the progress of surgery. In thrombosis of the intracranial sinuses with operation, results have been obtained. Thus Macewen had only 8 fatal cases in 28 cases. For the cure of infective thrombosis, all of which die without surgical intervention, this is a remarkable showing for this new operation.

Intracranial tension has very recently become a new indication for operative interference. This operation affords relief in a class of cases that heretofore were fatal. This operation is a contribution of modern surgery, and is another milestone which marks the progress of the science of surgery The recent advances in clinical medicine and clinical microscopy have opened up the heretofore unexplored field for operative interference. Cases of coma with no external injury of the skull have heretofore been treated by the expectant plan, with almost uniformly fatal results. Surgery owes much to these two departments of medicine for valuable knowledge upon a subject which is comparatively new, and which offers an additional field for operative work. Intracranial tension is a condition which a study of modern pathology has shown calls for surgical interference. Intracranial hemorrhage is one of the most frequent causes of intracranial pressure. It may also be caused by bone, pus, and foreign body. In order clearly to understand the theory of intracranial pressure, it is necessary to bear in mind two facts: (1) that the brain itself is incompressible; and (2) that the cranial cavity itself is incapable of expansion, therefore, the pressure of a clot of blood or a fragment of bone, or a collection of pus, or any foreign body, must be accommodated in the limited space in which the brain is lodged. If the foreign body is of sufficient size to fill the intracranial space by a twelfth, death results.

The treatment of intracranial tension is a new subject, and one which I have of late given special study. I am convinced that operative treatment is indicated in many of these cases. I have employed this measure with most gratifying success. The indications for operative interference are in some cases perfectly clear, while in others the phenomena present would not justify resort to so severe a measure. The greatest difficulty is to determine what the line of demarkation is between the cases that demand trephining or lumbar puncture, and those in which the plan of expectancy can be adopted.

These cases of intracranial tension can be divided into two classes as regards operative interference. The first class includes those in which intracranial tension is sufficient to produce profound coma. Operation will save patients included in the first class that uniformly died under the expectant plan of treatment. Operation will save the patients embraced in the second class when the symptoms are gradually increased in severity. In regard to the indications for operation to relieve intracranial tension in those cases included in the second class in which coma is not present, the problem is difficult of solution. I have been guided as to the operation by the condition of the patient after a study of the symptoms from hour to hour and from day to day. If the arterial pressure arises to a point and remains stationary, and the vasomotor system does not fail, even with a well-pronounced vagi disturbance, no operative procedure was practiced, and recovery has taken place. In addition to the symptom of increase of arterial pressure, the blood-count must be studied, the eye-grounds examined, the urine tested, the reflexes studied, the disturbances of cranial nerves noted, and all other phenomena investigated. If the pressure is not daily increasing, and the leukocytosis not rising, the red blood cells not increasing, and the urine not becoming glycosuric, the hebetude not emerging into coma, and the cephalalgia not increasing, delay in operative interference is indicated. If all the above-mentioned symptoms from a stationary point begin to increase, operative interference is called for to save the patient's life. If on the other hand, from this stationary point, all the symptoms show an improvement, operation can be deferred at least for the present, if not permanently.

The operation for relief of insanity is worthy of consideration. Surgery has accomplished great victories in the restoration of reason in the insane, when the lesion was due to traumatism. A little over a hundred years ago the management of the insane was most revolting and brutal. In Europe the treatment of the poor outcasts was a blot upon the civilization of the world. Imagine these poor wretched creatures consigned to dungeons and manacled by chains for years. In these dark prisons, the insane, considered as demons, were kept in irons amid squalor and filth. It has been stated that the iron tether was so short that these poor unfortunate victims could not even stand upright and were held for years by chains riveted around the neck or waist. The humane treatment of those poor unfortunate people began about a century ago and great credit is due to neurologists who have rescued these sufferers by throwing aside their manacles, by restoring to them their liberty, and by proffering them treatment. Men like Tuke and Pinel and Rush took the initiative in this great reformation. As soon as a rational, humane, kind treatment was instituted, it became evident here and there that among these insane, epileptic demons as they were called, there were some who could be relieved and sometimes cured. Surgery has been employed for this purpose, and some of the results are almost miraculous.

In the course of the development of surgery, operations have been devised for the relief of insanity where the etiology was due to pelvic disease. In DaCosta's monograph it is mentioned that Hobbs operated on 116 cases of pelvic disease in the insane, with a mortality of the operation less than 2 %, and recovery from the insanity in 51 %, and great improvement in 7 %. "In the group of non-inflammatory troubles, tearing of the perineum, uterine displacements, tumors, etc., 25.5 % regained mental health, and 31 % improved."

In the surgery of the heart great progress has been made. Bimanual massage of this organ has been successfully resorted to by Cohen in a case of collapse following chloroform narcosis and during laparotomy. In a case described by him: "Artificial respiration for two minutes having no effect, he introduced his hand into the abdominal cavity, pushed along the anterior abdominal wall until the diaphragm was reached, and placing the hand, palm upward, in about the position the heart would normally be, that organ was freely grasped through intervening diaphragm. There was an entire absence of heart action. Placing the right hand over the precordial region, externally, he now plainly palpated the heart as it lay between his hands, and began rhythmic compression, using both hands at a rate of about sixty a minute. After about thirty seconds a slight beat was felt by the left hand. The heart now began to beat slowly, gradually increasing in strength and rapidity until at the end of a minute the beats registered about eighty, and respiration began to be partially reëstablished. About two minutes after this, respiration was normal, pulse 80, and shock being apparently recovered from, the anesthetic was changed to ether, and the operation finished in about thirty minutes, with recovery of patient."

For the relief of pericardial adhesions, a new operation has been devised by Peterson and Simon. This operation is analogous to Estlander's operation for pleuritic adhesions. The operation consisted in a resection of a portion of several ribs, and in some cases a part of the sternum. Murphy cites the fact that of 38 cases of stab-wound of the heart, 90 % were penetrating, and only 19 % were immediately fatal, thus leaving 81 % of the cases amenable to surgical treatment. This new operation, the outgrowth of modern surgery, will afford a new field for this science to save human life in a class of cases heretofore fatal.

In addition to the surgery of the heart, there are many other operations of the chest that deserve mention as indicating the progress which surgery has made within the past century. In surgery of the chest the wounds of the pleura and lung have been successfully treated since the introduction of antiseptic surgery. Abscesses of the mediastinum, caries, and necrosis of the ribs and sternum, tumors of the chest-wall, actinomycosis, and other infective processes, removal of fluid from the pleural and pericardial cavities, are among the recognized operations of the day.

Wounds of the heart during the past century, and especially during the past 10 years, have been treated surgically with remarkable success. Stewart reports that Roberts, in 1881, suggested the propriety of suturing these wounds. Tillmann believed in the hopelessness of this procedure, yet in 1897, Rehn published the first successful case of cardiorrhaphy in man. Stewart likewise has operated with success, and he has collected 60 cases with the brilliant result of 38.3 % of recoveries.

In the surgery of the lung advance has been made within the last quarter of a century. The diseases of the lung which have become amenable to surgical treatment are tumors, tuberculosis, abscess, gangrene, hydatid cysts, actinomycosis, and bronchiectasis. Murphy has collected 47 cases of tuberculosis; 26 patients were improved and

19 died; 8 cases of actinomycosis, in which the patients recovered; 96 operations for pulmonary abscess, with 80 % of recoveries; 122 cases of pulmonary gangrene, with 66 % of recoveries; 57 operations on bronchiectasis, with 60 % of recoveries, but only half permanently cured; 79 cases of hydatid cysts of the lung, with about 90 % of recoveries. In some 400 cases of pneumotomy collected from various sources by Murphy there have been about 300 recoveries, or about 75 %. This is a most remarkable result in a department of surgery that has developed within a few years, and includes a class of cases that were formerly practically hopeless. Much credit is due to Murphy for his work as a pioneer in thoracic surgery. Perhaps one of the most interesting operations in connection with pulmonary surgery refers to tuberculosis of the lungs. In reference to excision of tuberculous foci, Whitacre has shown that in nearly 98 % the operation is "impossible and irrational." In only 2 % of the cases can surgery afford relief, and in these cases the foci are located in the apices of the lung. It is thus evident that there is little to be expected in the future as regards pulmonary surgery as it refers to tuberculosis, since careful investigation has demonstrated the fact that, as a rule, the tuberculous foci are not accessible to the surgeon. Before dismissing this subject the nitrogen compression method introduced by Murphy deserves recognition. The object of this method is to compress the diseased lung by gas, thereby restraining its movement to cause a mechanical obliteration of the cavity and the limitation of the already existing focus, to favor fibrosis, thereby closing in the avenues of dissemination to afford rest to the affected part in the same manner as a splint to a fractured bone. In certain judiciously selected cases this method is applicable.

In October, 1842, Sayre made a free incision in the chest in a case of empyema, and the patient made a good recovery. Forty-eight years ago Sayre raised the inquiry, "In the empyema of a tuberculous patient from the rupture of an abscess into the pleura, should we not be justified in tapping as soon as discovered?" In 1850, Dr. Henry Bowditch suggested and practiced paracentesis thoracis. Wyman, unaware of Bowditch's operation, performed the same operation. For a long time in this country, as well as in Europe, paracentesis thoracis was condemned; but at last the operation has advanced to the stage of full acceptance by all surgeons. It is almost impossible to estimate the number of lives saved by this operation, but the number is very great, and this operation forms an enduring monument to the fame of American surgery.

Surgery of the stomach has claimed attention only for the past quarter of a century, for previous to that time it was practically unknown. The unsatisfactory state of the surgery of the stomach previous to 1875 is best illustrated by a reference to statistics. It has been shown that of 28 operations attempted upon the stomach, there were 28 deaths, or a mortality of 100 %. From 1875 to 1884, improvement took place in that 163 operations were performed with 133 deaths, or nearly 82 % mortality.

The reduction of the mortality of 100 % to 82 % was a gain in the right direction; but it left much to be desired. The rapid strides which scientific surgery has made in the operations upon the stomach forcibly illustrate what can be expected in the future in this department of surgery. There are at present about 12 recognized operations upon the stomach, and in 7 of these there is practically no mortality, while in the remaining 5 it has been reduced to about 25 %. Keen predicts as technic improves the mortality in the most difficult operations ought not to be higher than 10 %.

I should predict, from an examination of late statistics, that even less than 10 % has already been accomplished, and in the future the mortality will be still lower. Mayo has shown that in an investigation of over 900 operations upon the organs contained in the upper abdominal zone there existed a relationship between gall-bladder and ducts, the duodenum, the pancreas, and stomach. In other words, that the continuity of tissue like the mucous membrane makes the disease of one organ a menace to the others. Mayo also believes that the duodenum, on account of its situation, acts as a buffer, and is involved secondarily in about an equal proportion of cases from gall-bladder disease and gastric ulcer, in the same way Mayo pointed out that diseases of the pancreas were secondary to gall-stone diseases.

Cardiospasm, in which there is difficulty in deglutition from a spasm of the muscles of the cardiac end of the stomach, forms a new indication for operation. It is comparable to pyloric obstruction, and the operation for the relief of cardiospasm is similar to that of pyloric stenosis. Mikulicz and others have performed this operation with brilliant results and effected a cure that could be obtained only by surgery.

Pyloric stenosis is another and new indication for operative interference to relieve the distressing symptoms so often disguised under the term of dyspepsia. In 1901 Roswell Park collected upward of 40 cases in which the patients were cured by surgery.

Gastroptosis is a prolapse of the stomach due to relaxation of the ligaments which support the organ. This condition gives rise to ordinary signs of dyspepsia accompained by acute pain and later emaciation. Modern surgery in its evolution has devised an operation for the relief of this distressing and painful condition. The stomach is elevated and held in its anatomic position by shortening of the gastrohepatic and phrenic ligaments of the stomach. Thus the normal ligaments are shortened and the stomach held in its proper position without disturbing its mobility or function. In eight cases reported, including four by Bier, seven patients were cured and one improved. This is a new operation of modern surgery calculated to relieve a distressing condition for which medical treatment was of no avail.

Dilation of the stomach has been operated upon with a view of relief of distressing symptoms to which it gives rise. The operation is called gastroplication and consists in reducing the capacity of the dilated stomach by tucking in folds of the stomach wall. It is a most satisfactory operation, provided there is no pyloric obstruction present. The operation is safe and effects a permanent cure.

Exploration of the stomach has been resorted to successfully by Dennis to relieve hysteric vomiting. Hysteria, as is well known, gives rise to persistent and uncontrollable vomiting, and in one case in which no relief could be obtained by medical means, a laparotomy was performed, the stomach drawn out and then returned into the peritoneal cavity. The psychic effect or the mechanical stretching of the stomach itself resulted in cure.

Gastrotomy for the removal of foreign bodies in the stomach has been resorted to successfully during the past 25 years. The foreign bodies enter the stomach as a result of accident or are purposely swallowed as a livelihood, or on account of insanity. In preantiseptic days, Murphy reports 19 cases of gastrotomy, with 15 recoveries and 4 deaths, or a mortality of 21 %. In antiseptic days, 71 patients were operated upon, with a mortality of 9 %. This includes early and late cases and at the present time if the cases are seen early the mortality is very low. Thus, modern surgery has developed to such a state of perfection that the stomach can be opened and foreign bodies removed with almost a certainty of success.

Gastrostomy is an operation employed for the relief of stricture of the esophagus, either benign or malignant, or for certain lesions connected with the stomach itself. It has for its prime object the prevention of death by starvation.

In 1883 Le Fort compiled some statistics in 105 cases of gastrostomy, in which he showed that the mortality from 100 % was reduced to 74.2 %. In 1885 Zisas collected 162 cases of gastrostomy, with 113, or 69.7 % of mortality. In 1886 Knis had 169 cases of gastrostomy, with a mortality of 66.6 %. In 1887 Heydenreich collected 33 new cases of gastrostomies, with 19 deaths, or 57 % mortality. Since 1887 Guerin has collected 121 cases of gastrostomy, with 43 deaths, or 35.5 % mortality. Mayo has performed gastrostomy with a much smaller death-rate than any mentioned. There can be no more beautiful illustration of the development of surgery than is demonstrated in this one operation, since formerly it was attended by a mortality of 100 %, while to-day, after about a quarter of a century the operation has by evolution achieved a record that is most remarkable, since the latest figures show the mortality to be less than 30 %.

Mikulicz recently performed 10 gastrostomies for the relief of non-malignant strictures of the esophagus, with only 7 deaths, or a mortality of about 20 %.

Dennis operated upon a case of impermeable stricture of the esophagus, caused by ulceration and cicatricial contraction by typhoid ulcers. This case is one of the two in which typhoid ulcers have been found. The patient is now living, seven years after the gastrostomy. His weight previous to the operation was less than 100 pounds, and to-day it is 184 pounds. He had not taken a mouthful of food except through the fistulous opening for several years and is perfectly well nourished.

Gastric ulcer has become a recent indication for operation. It has been performed 184 times as collected by Mayo Robson up to 1900. These 184 cases do not include those for perforation or hemorrhage; 157 patients recovered, and 31 died, thus giving a mortality of 16.4 %. In 1901 statistics show that in 25 % of cases of gastric ulcer the patients died under medical treatment, and only 5 % under surgical treatment, according to the latest statistics. Gastric ulcer is a pathologic condition which formerly was considered exclusively from a medical point of view. To-day this disease in the stage of complication has been relegated to the domain of surgery. It has been during the past quarter of a century that progress has been made in the management of the serious complications, such as hemorrhage and perforation, of this intractable disease. Under medical treatment, the mortality of gastric ulcer in hemorrhage or perforation was nearly 100 %, while under surgical treatment this frightful mortality has been reduced by the Mayos to 5 % in the benign ulcers and 18 % in the malignant ulcers. The advance that surgery has made in this disease has been in the study of the mechanics of the stomach, rather than the chemistry. Medical treatment based on chemistry was of little avail. Gastric ulcer of the stomach affords a striking illustration of the progress of surgery within the past decade. In addition to the reduction of the mortality from nearly 100 % by medical treatment to about 5 % by surgical treatment in the acute cases of hemorrhage and perforation, to 23 % in the chronic cases with malignancy, there has been eliminated the danger of cancer engrafted upon an ulcer which at the beginning was benign.

Gastric hemorrhage is a condition which has been relieved through the mediation of modern surgery. These hemorrhages from the stomach are peculiar in that the smallest ulcers, which can scarcely be recognized by the naked eye on post-mortem appearances, have given rise to fatal hemorrhage. Mayo reports five cases of acute perforation and hemorrhage with three deaths.

Cancer of the stomach was a uniformly fatal disease. Under medical treatment no patient ever recovered. Surgery has entered this domain, and already the beneficent results are beginning to be felt. It must be remembered that this invariably fatal disease reaches, according to Haberlin, 40 % of all the cases of cancer that invade the human body. Here is the most important and serious problem with which surgery has been confronted. Mayo assigns three reasons why surgery has never until recently interested itself in this fatal disease: (1) a belief that cure cannot be accomplished; (2) that the mortality of radical operations is almost prohibitory; (3) that the diagnosis cannot be made until the case is hopeless. In regard to the first reason, Mayo cites the fact that McDonald found 43 cases of cancer of the stomach, in which a permanent cure was effected by operation. Murphy collected 189 cases, in which the operation was performed by several operators, with 5 % permanent cures in cases of over three years' standing. In some of these cures the patients were operated upon more than two years, and hence would, by law of average, survive to bring the percentage up to 8 %. Beside these recoveries, Krönlein has proved by his statistics that human life is prolonged 14 months over the unoperated cases. These facts are in striking contrast to the uniformly 100 % mortality under medical treatment. The second reason why surgery has never generally entered the operative field for the relief of gastric cancer was due to the high mortality of 60 % which Billroth published. This mortality has been happily reduced to 10 % by improvement in technic and by early operation. If the operation is performed before adhesions have formed, and by men thoroughly trained in this field of operative work, the mortality will soon be even less than 10 %. Mayo has had 41 cases of excision of the stomach, with a mortality of 17 %. Out of the total number, 13 were performed by an improved method, with only 1 death, or 6 %, while in the last 11 cases of excision of the stomach there was not a death, or the mortality zero. The mortality has been reduced in Mayo's last series of 11 cases to zero, from 60 %, as reported by Billroth. No other statistics can be adduced to show so emphatically what surgery has achieved within a period of time that has elapsed since the erection of this magnificent building in this wonderful exposition. This one fact alone is the grandest and most striking proof of the miraculous work which surgery has accomplished, and to Mayo is due the credit of leading the world in this new department of surgery, which may be said to be the highest, the final, the most triumphant monument of the contribution of surgery to the human race. Here, again, is another striking illustration of what surgery has achieved. It has reduced the mortality of an operation in cancer of the stomach from 60 % to 10 %, and in a limited number to zero, and with every prospect in the near future of even a mortality of less than 10 % in a large series of cases.

The third reason why surgery has not invaded this field lies in the fact that the diagnosis cannot be made by medical means in time to effect a cure. Exploratory incision to find out is recommended by Mayo, and by this means an early operation can be performed that will be attended by small mortality as regards the operation itself, and a large percentage of cures as regards the disease itself. Cancer of the stomach, as a rule, is situated near the pylorus, just below the lesser curvature. Moynihan states that from this focus it spreads widely through the submucosa, and rapidly toward the cardia, and slowly toward the pylorus. Until very recently no surgery has been done upon the stomach for cancer, for the reason that it was considered a hopeless disease. Murphy collected 189 cases in which radical operation was done, with 26 deaths. Of these, 17 patients survived three years, or about 8 % of cures. This is a gain in the right direction, since all patients die without operation. This 8 % of cures was reduced to 5 % by a return of the disease after three years. Mikulicz in 100 cases had an average duration of life of 15 months. The patients had relief from suffering at least 15 months, and there did not follow that terrible suffering so characteristic of the inoperable cases of cancer of the stomach. The reason that the results are not better in cancer of the stomach is owing to delay in operation, and when that obstacle is overcome the results will be brilliant, compared with the gravity of the disease. Time permits of adhesions, and when the operation is resorted to before adhesions form, the mortality is very much lessened. Thus Haberkaut had a mortality of 72 % in cases with adhesions, and only 27 % without adhesions. Gastrectomy was done, as reported by Murphy, in Kappeler's clinic, with 26 % mortality, Krönlein with 28 % mortality, Kocher 29 %, Roux 33 %, and Mikulicz 37 % mortality. Murphy has called attention to the prophylactic treatment of cancer. He believes in the removal of conditions which seem to be essential in the majority of cases to the development of the disease. Mikulicz has shown that 4 % to 5 % of the human race suffer from gastric ulcer, and that a fifth die as a result of the gastric ulcer. The other factor which largely influences the growth of cancer is the pyloric stenosis when the stomach cannot empty itself. The suggestion, therefore, is the removal of gastric ulcers by excision, and the relief of the pyloric obstruction by gastroenterostomy, and these prophylactic operations when performed early are attended with a comparatively small mortality, eliminates the possibility of cancer of the stomach arising from these two important and frequent causes.

Partial gastrectomy was twice performed by Langenbuch and published by him in 1894. In both cases seven eighths of the stomach was removed. In 1898 Krönlein records all his own cases of partial excision of the stomach and Schlatter's case of complete excision. There were in all 24 cases, with 5 deaths, or a mortality of about 20%. Maydl, in 1899, reports 25 cases of cancer of the stomach, in which a partial gastrectomy was performed, with a mortality of 16%. Of the patients who recovered from the operation, 7 had recurrence very soon afterward, and the average duration of life was 11.7 months. In 1898 Kocher has reported 57 cases of resection of the pylorus, with 5 deaths, or a mortality of 8%. In the list there were 8 patients cured. Rydygier, in 1901, reported 25 partial gastrectomies, in which 8 patients recovered and 17 died, or a mortality of 68%. Czerny, in 1899, reports 29 partial gastrectomies, with 11 deaths, or a mortality of about 40%, and the average duration of life was 22 months. Morison reports 16 cases of partial gastrectomy, with 7 deaths, or a mortality of about 43%. Two of Morison's patients are still living. In one 6 years have elapsed, and in the other about 4 years. Mayo reports 48 cases of partial gastrectomy for pyloric cancer, with a mortality of 12.5%, and in the last 19 cases there was only 1 death.

Complete gastrectomy was first performed by Conner, of Cincinnati, in 1883. The patient died upon the operating table. Complete gastrectomy was performed by Schlatter in 1897. The patient lived 13½ months. Complete gastrectomy was next performed by Brigham in 1898. The patient recovered from the operation. Complete gastrectomy has been performed 12 times, as reported by Robson and Moynihan. Four died as result of the operation, or a mortality of 33%. These cases are too recent for a pronounced opinion as to the permanency of the cure.

Surgery of the liver forms a unique chapter in the development of the science. Operations upon the gall-bladder and biliary ducts afford the most striking illustration of what modern surgery has achieved. Within the past 37 years this new operation has been performed with most gratifying results. It is a source of great national pride that this operation, destined to relieve so much intense suffering and to save life itself, was discovered in this country. To Bobbs of Indianapolis is due the great honor of the discovery of an operation which has accomplished these two beneficent results. In 1867, 37 years ago, Bobbs performed successfully the new operation of cholecystotomy and removed 50 gall-stones by an incision into the gall-bladder. This event marks an epoch in abdominal surgery that places this renowned Western surgeon upon a pedestal that commands homage and respect from the civilized world. Bobbs's first cholecystotomy was soon followed, in 1868, by a second operation by another American surgeon, J. Marion Sims, who removed 60 gall-stones from the gall-bladder. To Tait, however, who was at the time of his death the greatest authority on hepatic surgery, belongs the great credit of perfecting the technic of this operation. Excision of biliary calculi by incision into the umbilical vein was performed by Dr. John C. Warren of Boston within the century. Such in brief is the history of the operation, the development of which from its crude to its almost perfect technic, forms a remarkable chapter in surgery.

Gall-stones with intestinal obstruction are attended under medical treatment, with a mortality of nearly 100 %, while surgery has brought relief in a certain proportion of cases and with every encouraging prospect of a very great improvement. Courvoisier reports 125 cases, with a mortality of 44 %; Schüller had 82 cases, with a mortality of 56 %; Eve 28 cases, with a mortality of 40 %; and Bannard 8 cases, with a mortality of 57 %.

Cholecystotomy is an operation which consists in opening the gall-bladder for the relief of various conditions. Cholecystitis or inflammation of the gall-bladder is a disease that was formerly treated by medical means, with little or no prospect of cure if septic infection was present. In those cases in which gangrene or pus or rupture has occurred, medical treatment is attended by death; but surgical treatment may effect a cure in a large percentage of cases. Cholecystotomy is one of the most gratifying operations in surgery, because it relieves suffering, effects a permanent cure, and is attended by the exceedingly low mortality of less than 3 %. The statistics of the operation of cholecystotomy varies greatly, owing to the special conditions for which the operation is performed. Mayo Robson states that when the operation is performed for simple disease, as gall-stones, when malignant disease and jaundice with infective cholangitis are absent, the mortality in 281 cases was only 1.06 %. If now the complicated cases are included, such as phlegmonous cholecystitis, gangrene of gall-bladder, infective cholangitis with or without gall-stones, the mortaliy is only 2.7 %. If further the malignant cases be collected, in which cholecystotomy has been resorted to in the presence of cancer of the pancreas or bile-ducts, the mortality of the operation itself in 22 cases was only 5.8 %. As regards the recurrences, the statistics will be mentioned latter. Mayo reports, in 1902, 227 cases of cholecystotomy for various simple conditions, chiefly for gall-stones, with 6 deaths, or a mortality of 2.6 %. The same operator reported, in 1903, 352 cholecystotomies for simple conditions, with 8 deaths, or a mortality of 2.27 %. For malignant disease the same surgeon reported, in 1902, 4 cholecystotomies, with 2 deaths, or 50 % mortality, and in 1903, 5 additional cases, with 3 deaths, or 60 % mortality. It is thus evident that cholecystotomy is attended by a high mortality when the operation is performed for cancer. It must be remembered, however, that the mortality is 100 % under medical treatment. The mortality of 100 % under medical treatment will never be improved, while the 50 % or 60 % mortality under surgical treatment will be reduced as diagnosis and technic improve, and early operation is performed. Kehr, in 1896, reported 209 cholecystotomies upon 174 patients. In the simple cholecystotomies, the mortality was only 1 %. In the complicated cases the mortality was 58.8 %. In a later series Kehr reported 202 cholecystotomies with 32 deaths, or a mortality of 16 %. The higher mortality in this series is accounted for by the greater severity of the cases which earlier did not submit to operation. In conservative cholocystotomies Kehr had 68 operations with three deaths, or a mortality of 4.4 %. In 1902 Kehr again reported his statistics, which consisted of 720 operations for gall-stones, with a mortality of 15 %. In the simple cases of cholecystotomy the mortality was 2.1 %, and in the complicated cases, including cancer, the mortality was 97 %. Greig Smith reported 11 simple cholecystotomies with no mortality, and one complicated case with death, or 12 cases in total, with a mortality of 8.33 %. Lawson Tait reported 55 cases of cholecystotomy with three deaths, or a mortality of 5.4 %.

Thus in cholecystotomy alone is an operation that has shown a steady improvement in its statistics. In no other operation is a greater contrast between the medical and surgical treatment of a disease at the present day.

Cholecystectomy is an operation which consists in excising the gall-bladder in a manner somewhat similar to the removal of the appendix. Ferrier reported, in 1901, 16 cases with 4 deaths, or a mortality of 25 %. Courvoisier reported 47 cases with 12 deaths, or a mortality of 25 %. Martig, in 1894, collected 87 cases of removal of the gall-stones with 15 deaths, or a mortality of 17.2 %. Mayo Robson reports 28 cases with 4 deaths, or a mortality of 14.2 %. Mayo, in 1902, had 31 cases with 3 deaths, or a mortality of 9.6 %, and in 1903 had 70 cases with 3 deaths, or a mortality of 4.3 %, and up to the present time he states that he has had 204 cases with a mortality of 4 %. Kehr reported 21 cases with 1 death, and a mortality of 5 %, and later another list with the mortality of 3 %. Thus in cholecystectomy is another operation that has shown steady improvement in its statistics. This operation affords another illustration of the marked contrast between the medical and the surgical treatment, for in the former treatment no cure can be effected, while in the latter the percentage is very large.

Choledochotomy is an operation which consists of opening one of the biliary ducts and is a more formidable operation than opening the gall-bladder. Ferrier, in 1893, reported 20 cases, with a mortality of 25 %. Kehr, in 1896, reported 84 cases, with 31 deaths, or a mortality of 37.8 %. In a later series his mortality was reduced to 12.5 %. Mayo states that in 130 cases of benign series he had a mortality of 7.75 %. Mayo Robson reported, in 1901, 37 cases, with 4 deaths, or a mortality of 10 %, and since 1901 51 cases, with 1 death, or 1.9 %, and later a consecutive series of 52 choledochotomies with no deaths. Choledochotomy is one of the most difficult operations in surgery, and the advance which surgery has made is shown by a reference to the great mortality of these cases for which this operation is performed, since under medical treatment suffering was not relieved and death often supervened, whereas under surgical treatment the mortality has been reduced even to 1.9 %.

Cholecystenterotomy is a modern operation on the biliary passages, and consists in establishing a new communication between the gall-bladder and the intestine. Murphy reported 23 cases by use of sutures, with 8 deaths, or a mortality of 34 %; 21 cases by Murphy's button, with no mortality, and 2 cases for malignant disease, with 2 deaths, or a mortality of 100 %.

Cholecystduodenotomy has been performed by Murphy's button in 67 non-malignant cases with only 3 deaths, or a mortality of about 4 %, and in 12 malignant cases by Murphy, 10 died, or a mortality of 83.3 %. Mayo performed cholecystduodenotomy on 5 patients for chronic pancreatitis with no death, and 4 times for cancer with 1 death, or a mortality of 25 %.

Pancreatic disease affords a field for the display of what modern surgery has achieved that astonishes the scientific world. Körte has computed the mortality of the operation for the cure of pancreatic cysts, and shows that Gussenbaur was the first to operate for the relief of this fatal disease. Previous to Gussenbaur's operation, the mortality under medical treatment was 100 %. In the 84 cases collected by Körte, five patients died as the immediate result of the operation, thus giving the low mortality of not quite 0.6 %. This statement seems incredible and affords the most startlingly unprecedented illustration which has no parallel in any other science. This operation has attracted great attention in the scientific world and its brilliant and unique record has been heralded throughout Christendom. Still more striking is another report of 15 cases of complete excision of the cyst of the pancreas with 13 recoveries, or a mortality of about 13 %, and in 7 additional cases the extirpation has been only partial, since some of the cyst-wall was so adherent to important structures that its removal was impossible and 4 of the patients died, thus giving a mortality of 57 %, which in contrast to 100 % mortality under medical treatment is a great advance, though it is admitted that it is not what is expected, since as technic improves, the operation will be brought perhaps nearly as low as simple ovariotomy in the future. In evacuation and drainage of the pancreatic cyst there have been collected by Takaysan 17 cases with 1 death, a mortality of not quite 6 %. Mayo had 5 consecutive cases of chronic pancreatitis with recovery in each case, and 4 cases of cancer of the pancreas with 1 death, or a mortality of 25 %. Operations upon the pancreas afford another brilliant example of the achievements of surgery within the past few years. Mayo Robson and Moynihan, in 1902, reported 24 operations for the relief of chronic pancreatitis with 2 deaths and complete and perfect recovery in the 22 remaining cases. There is no more striking example of the progress which surgery has made than is afforded by this record. In cancer of the pancreas, which is always fatal, the operation has been attended by about 50 % mortality, and in the other 50 % the patients have survived a comparatively short period. This is an operation in which surgery in the future will have a better showing just as soon as the methods of diagnosis are improved so as to operate in the early stages of the disease. Mayo has had 37 cases of pancreatic disease with 2 deaths, or a mortality of about 5 %.

Surgery of the spleen offers an illustration of the progress which surgery has made during the past century. The cases of major operations upon the spleen are too few to make any extensive and reliable statistics. The prognosis which is most marked, and which interests us in connection with the subject of this address, shows improvement each year. Thus Murphy shows that in 1890, in the operated cases, the mortality was 70 %. In 1897 the mortality was 37 %. In 1899 the mortality was 26 %. These figures are unsatisfactory, except to point out that in this new department of surgery great advance is made each year. Fevrier grouped under four heads the surgical conditions in the spleen that call for operative interference. They are traumatism, abscess, tumors, and displacements. As these conditions were nearly all fatal without surgical intervention, it is interesting to inquire what surgery has accomplished in this new field. Fevrier collected 56 cases of rupture of the spleen, in which splenectomy was performed 46 times, with 23 recoveries, thus giving a mortality of 50 %. There were 8 cases of stab and gunshot wounds, with 3 deaths, or a mortality of 30 %. Abscesses and hydatid cysts have called for operative interference, but there are no reliable statistics on the results. Malarial splenomegaly was operated upon 117 times, with 31 deaths, or a mortality of 26 %. Displacements of the spleen have been operated upon by spenectomy and by splenopexy. Cases of extirpation of a movable spleen have been collected by Stierlin, who shows that the mortality is now only 6.25 %. Splenectomy in echinococcus of the spleen, according to Bessel-Hagen, previous to 1890, was attended with a mortality of 60 %, and from 1891 to 1900 the mortality was reduced to 10 %.

Tuberculous peritonitis has been taken out of the realm of internal medicine and transferred to clinical surgery. It has now become an established routine of practice that laparotomy is justifiable in cases of ascites in which the etiology does not depend upon disease of the liver, kidney, or heart. The method of invasion of the bacilli in their attack upon the peritoneum varies in different cases. The bacilli in rare instances may gain entrance through a perforation from a tuberculous intestinal ulcer, or from a purulent tuberculous vaginitis. Again, the peritoneum may become infected through a perforating tuberculous appendicitis, or from a tuberculous ovary, or fallopian tube. Williams, of the Johns Hopkins University, has shown that from 40 % to 50 % of the cases of tuberculous peritonitis can be traced to this origin. Abbe has demonstrated that about 66 % of the cases of tuberculous peritonitis are due to infection of the thoracic lymph-nodes, and in only 16 % is entrance gained by the mesenteric glands. It is thus evident that, while 16 % of the cases of tuberculous peritonitis can be explained by infection through the alimentary canal from milk or other kinds of infected food, the great proportion is due to infection from the thoracic lymph-nodes. There is little doubt but tuberculous peritonitis may arise as a secondary affection following tuberculosis of the intestinal canal. Here again inhibition of infected milk and meats play an important rôle. The entrance of tuberculous sputum into the stomach in those affected with pulmonary tuberculosis explains intestinal and peritoneal infection. The latter method of invasion is considered a frequent cause of peritoneal tuberculosis. The presence of tuberculous ulcers in the stomach in phthisical patients who subsequently suffered from intestinal tuberculosis has been thus explained by the investigation of Klebs. Many experiments upon lower animals which were fed by food containing tuberculous sputum and fragments of tuberculous lung have proved beyond doubt that intestinal and peritoneal tuberculosis can arise in this way. It is a strange clinical fact that laparotomy for the cure of this disease has become established as a recognized procedure through errors of diagnosis. Sir Spencer Wells cured a case of tuberculous peritonitis by a laparotomy performed under the supposition that it was ovarian disease. Laparotomy, however, as a curative measure, was first introduced by Dr. Van de Warker, of Syracuse, N. Y. He blundered upon a case of tuberculosis of the peritoneum, under the supposition that he was operating for the cure of a case of hydrops of the peritoneum. Dr.

Van de Warker presented this case at a meeting of the New York State Medical Association in 1883. From this time on, the operation of laparotomy for the cure of tuberculosis of the peritoneum has been practiced. The operation has, however, been modified from year to year; but most surgeons still adhere to the simple operation at first devised by our American surgeon. As regards the result of laparotomy for the cure of tuberculous peritonitis, surgeons differ largely in their statistics. Parker Syms shows that some claim 80% of cures, while others 24%. Marked improvement follows in 80% of the cases, and the mortality of the operation is only about 3%. Syms concludes that it is safe to estimate that 30% of the cases of tuberculous peritonitis are permanently cured by laparotomy.

In suppurative peritonitis surgery has opened up a new field within the past few years. The operation of incision into the peritoneal cavity has effected cures in a class of cases that heretofore were uniformly fatal. Murphy reports 7 recoveries out of 9 cases, or 77% of recoveries in diffuse suppurative peritonitis following appendicitis, while Dennis has had 11 cases of diffuse suppurative peritonitis without a death.

The radical cure of hernia presents one of the most forcible illustrations of the onward march of surgery. Coley reports 1003 operations with a mortality of less than a fifth of 1%, and with relapses of less than a tenth of 1%. When it is considered that nearly one person in every 20, and even by some statisticians one to every eight, persons is born with a rupture, and these patients must wear trusses, the bane of human existence, and which are as necessary to the comfort and safety of the patient as a splint is to a fractured leg, the untold blessings of this one contribution of surgery to the human race become strikingly apparent. In other words, surgery offers to the thousands affected in this way a sure, perfect, and safe cure, and with the complete elimination of the uncomfortable, inconvenient, often painful, and sometimes dangerous instrument of barbaric times, the truss. What aseptic surgery has accomplished for the human family in the relief of this one distressing and common condition, no one can appreciate except he who has been the recipient of this blessing offered to him by the science of surgery. Until recently great expense was incurred and time consumed in fitting trusses. Many of these patients died as a result of strangulated hernia, which formerly had a mortality of over 50%. Now the possibility of strangulated hernia is eliminated and a radical cure effected with less than 1% mortality and 1% relapse. Perhaps one of the most forcible arguments to show the effect of certain improvements in the technic of surgical operations is demonstrated by the use of rubber gloves. In 116 cases of hernia operated upon at the Johns Hopkins Hospital prior to 1896, there were 28 cases of suppuration in the wounds, or 24%, while in 226 cases of the same operation with rubber gloves upon the surgeons' hands there were 4 cases of suppuration, or a fraction over 1 %.

In umbilical hernia Mayo has devised an operation that offers relief to those patients who heretofore followed a life of constant suffering and danger. Mayo first performed his overlapping operation in 1895, and in a series of 50 cases there was no mortality and no relapses except in which the relapse was only a partial stretching.

The operation for the relief of acute appendicitis is clearly traced to the work of American surgeons. In 1843, Willard Parker, and later Gurdon Buck, did much to explain the nature of these iliac inflammations, and Sands cleared the way for the perfected operation of McBurney, which aims to prevent these dangerous peritoneal inflammations, and to prepare the wound for aseptic healing. Sands also first operated with success after perforation had taken place and general peritonitis was present. To McBurney is due great credit for the perfection of this operation, which is now recognized throughout the world as the best, safest, and most scientific way of managing these varieties of suppuration hitherto so fatal. The operation of removing the appendix vermiformis during the quiescent period between relapsing attacks was suggested by Sir Frederick Treves, of London, although the appendix was successfully removed in this country by Dennis in 1887. In this case the appendix was diseased, owing to adhesions to an ovarian tumor.

The surgery of the appendix is most interesting with a view to a study of what surgery of the past century has accomplished. There is probably no surgical disease about which so much has been written as appendicitis. The subject is trite and threadbare in many respects. There is little to be learned in regard to the etiology, symptomatology, and diagnosis of the disease. The operative technic can be but little improved upon in its present state of perfection. The mortality under proper antiseptic and aseptic conditions is so low that in the nature of the disease it will never in all probability be brought much lower. The percentage in these days of aseptic surgery in this abdominal operation is less than the percentage in the simple amputation of the finger in the preantiseptic days. It would seem that surgery had reached its climax in regard to mortality in operation for the relief of appendicitis, yet the time will never come when there will be no death-rate. Complications are certain to arise that are beyond the control of the surgeon. Crural thrombosis, intestinal obstruction, acetonemia, embolism, shock of operation, intercurrent affections, all afford examples to show that some mortality must always exist. If a fraction of a per cent can be gained in the reduction of the mortality, it is an advance in the right direction. The experience of surgeons during the past few years has demonstrated new methods, has pointed out new ways, and has discovered new facts, all of which tend to reduce the mortality. It seems now the only thing that is left is to combine the various views of experienced surgeons into some uniform plan of treatment, in order to produce the best results. The mortality in appendicitis in all cases under medical treatment is about 16 %, with 30 % of relapses, while in diffuse suppurative peritonitis it is almost uniformly fatal.

The mortality in appendicitis in all cases under surgical treatment is about 4 %, and with no relapses, and in diffuse suppurative peritonitis the mortality in published statistics is from 31 %, the lowest, to 91 %, the highest, and in my 11 consecutive cases of diffuse suppurative peritonitis the mortality was zero.

Ochsner has recently contributed some statistics from his own operations during one year, which reflect great credit upon his excellent work. In the acute there was a mortality of 3 %, and in the chronic cases there was a mortality of 1 %. In the entire number of cases, both acute and chronic, there was a mortality following the operation of 2 %. Deaver has also recently contributed some statistics from his own operations extending over a period of one year, which likewise reflect great credit upon his surgical skill. In the cases of general diffuse peritonitis there was a mortality of 31 %. In the cases in which there was abscess there was a mortality of 12 %. In the cases in which the disease was confined to the appendix, with stricture, ulceration, and necrosis of the mucous membrane, there was a mortality of 0.8 %, and finally, in all the cases operated upon, the total mortality was 5 %. Richardson's published statistics are practically the same, and the result of these various operators gives an idea of what surgery has accomplished. In a study of the last 119 cases of appendicitis occurring in my practice up to April 1, 1903, the mortality of the disease, irrespective of operation or of any special plan of treatment, was a little over 1.5 %. In the cases treated without operation in which the attack was a mild, catarrhal one, and in which the patients were not operated upon during the attack, the mortality was zero. In this group of cases in which conservatism was employed for special reasons, the appendix was in many cases subsequently removed owing to repeated attacks, and the mortality was zero. In the group of cases in which the appendix was gangrenous and had ruptured into the peritoneal cavity with a general peritonitis, of which there were 11 cases, the mortality was zero. In the cases in which there was an acute perforative appendicitis, and in which the appendix was gangrenous, and found in a circumscribed abscess cavity, the mortality was 7 %. If now, in this group, all the operative cases are collected, both acute and chronic, the death-rate was 2 %. If the two fatal cases in the entire list of 119 cases are eliminated, which were hopeless from the start, but which were operated upon because it was offering the only possible chance of life, forlorn as the prospect was, the mortality of the disease was zero. The mortality of the operation both for acute and chronic appendicitis was also zero. Such cases as the two in which death occurred will always happen, and will always prevent the absence of mortality in the disease. In other words, if the two fatal cases are eliminated on the ground that surgery is powerless to save when complications such as empyema and abscess of the lung exist, the mortality in the medical and operative treatment of this disease in 117 consecutive cases was zero. The two deaths which make the mortality of the operation in all cases about 2 %, which in itself is insignificant when the nature of the disease is considered, deserve special consideration.

Richardson, of Boston, reports 574 appendectomies in the interval, with no deaths. Mayo has had 1668 cases in the interval, with two deaths, one from pneumonia secondary to an intercurrent attack of grip, and the other to surgical kidney following the use of catheter in an enlarged prostate.

Acute intestinal obstruction is a condition in former years almost universally fatal, while to-day surgery has afforded relief in this disease. Thus Wiggins gives a mortality of 67.2 % for laparotomy. Excluding cases in which either the operation was abandoned, the bowel incised, and an artificial opening made, resection attempted, or an anastomosis effected, there are 45 cases, in which 24 resulted fatally, or a mortality of 53.4 %. Counting only the operations that have been performed since 1889, and throwing out those cases in which the operation was not completed, we have a total of 18 cases, of which 14 were successful, and 4 unsuccessful, giving a mortality of only 32.2 %. This Wiggin believes to be a fair estimate of the risk to-day of laparotomy performed in a young infant for the relief of this condition, if performed within the first 48 hours of the onset. This gives a chance of success represented by 78 %, which, according to this author, would speedily rise to 90 %, as the patients come more frequently to operation during the first 24 hours.

Cancer of the bowel is a uniformly fatal disease. The recent advances in surgery have been the means of saving some of these patients. Mikulicz and Körte have each reported 12 cases of operations in which 9 of these cases had no return after four years, which is equal to 37 % of permanent cures. Dennis operated upon a patient with cancer of the cecum, resecting six or seven inches of the bowel, and subsequently making an anastomosis with Murphy's button. The patient is now perfectly well after a lapse of many years since the operation.

Laparotomy was performed by Dr. Wilson, in 1831, for the relief of intussusception. The patient was a negro slave, and had suffered from intestinal obstruction for 17 days. The abdomen was opened, the intussusception was found, and it was drawn out and released, and the patient made a complete recovery.

In 1809 Physick was the first to ligate the éperon, when an artificial opening had been made in the intestine on account of pathologic changes. In 1847 Gross urged the excision of a section of the intestine, with suturing of the divided ends, with a view to establish the continuity of the canal, but the patient refused, and in 1863 Kinloch, of South Carolina, accomplished this result. In 1834 Luzenberg laid open a strangulated hernia, found it gangrenous, excised the mortified section of the intestine, stitched the serous surfaces, and the patient fully recovered. This same surgeon suggested, in 1832, exclusion of light to prevent pitting of small-pox. The operation of laparotomy for the treatment of penetrating gunshot and stab wounds of the peritoneal cavity was the work of American surgery. Gross, in 1843, and Sims, just before his death, both suggested this method, but these surgeons never practiced this method of treatment. It remained for Bull, of New York, to make the practical application of the method, and to him is due the credit of this great advance in surgery. It is a source of national pride that laparotomy in penetrating wounds, and visceral injuries of the abdomen, was conceived, developed, and perfected in America. The widespreading influence of this operation is felt in abdominal surgery, and much of the present advance is the result of Bull's surgery.

Cancer of the rectum is a disease which was formerly uniformly fatal. Modern surgery has, however, rescued many of these unfortunate victims from a most distressing and painful death due to inanition, hemorrhage, and exhaustion. Taking the three-year limit as a point when it can be fairly stated that a return is rare after an operation, Krönlein collected 640 cases with a cure of 14 % of over three years' lapse of time from the operation. Czerny, Bergmann, Kraske, and other surgeons report from 20 % to 30 % of permanent cures, and Kocher has had as high as 50 % of permanent cures. The statistics of Kocher will be even improved upon as technic is perfected and early operation performed.

The first and only successful case of *laparotomy for the relief of perforation of the intestine* during the progress of typhoid fever was performed in this country, and to Dr. Weller Van Hook of Chicago is due the credit of having first established an operation for the relief of these cases, which hitherto were fatal.

Perforation in typhoid fever has given rise to an operation for the relief of fatal suppurative peritonitis. This operation is one of the most signal triumphs in modern surgery. In 1884 Leyden suggested and Mikulicz performed the operation. Haggard collected 295 cases in which operation was done up to May 1, 1903. Haggard states that 500,000 cases of typhoid fever occur in this country alone every year with a mortality of about 10% to 15%. Thus 50,000 to 75,000 patients perish annually from this disease. Osler states that a third of the deaths in typhoid occur as a result of perforation and "Taylor thus estimates that 25,000 deaths occur yearly from this accident. On a basis of a possible 30 % recovery by operative interference he further concludes that 7500 persons perish in the United States each year who might be saved." The mortality of perforation in typhoid is estimated by Murchison at 90 % to 95 %, and Osler says that "he could not recall a single patient in his experience that had recovered after perforation had occurred." Harte has shown that the mortality has steadily decreased as earlier operations were performed and technic improved; thus in 277 cases in successive intervals the mortality was as follows:

1884 to 1889,	10 cases;	mortality	90.0 %
1890 to 1893,	16 "	"	87.5 %
1894 to 1898,	110 "	"	74.5 %
1899 to 1902,	141 "	"	66.6 %

Duodenal ulcer has been operated upon with great success and is a signal illustration of what modern surgery has accomplished. Mayo operated upon 56 patients, in which 6 of the operations were for the relief of acute condition, with 3 deaths, or a mortality of 50 %; and 50 operations for the relief of chronic condition, with 1 death, or a mortality of 2 %. This operation marks an important epoch in the history of surgery. When the nature of the lesion is considered, the record is a most brilliant one. The difficulties of the diagnosis can only be appreciated when it is considered how similar are the symptoms of duodenal ulcer with pyloric ulcer, gastric ulcer, gall-stones, and other neighboring lesions. A few years ago there was no surgeon who was bold enough to attempt this life-saving operation. The uncertainty of the diagnosis and the frightful mortality that would have ensued made this operation for the relief of duodenal ulcer impossible.

Penetrating wounds of the abdomen are treated at the present time by an exploratory laparotomy, the value of which operation is evident by statistics reported by Postemski in 1891, in which he demonstrated that 60 % to 70 % of 645 cases of penetrating wounds of the abdomen terminated fatally, while the mortality was 100 % when the abdominal viscera were injured. In a later series of penetrating abdominal wounds there were 36 uncomplicated cases, in which the patients were treated by exploratory laparotomies; all recovered, and 22 cases of penetrating wounds of the abdomen associated with intra-abdominal injury, in which 12 patients recovered.

Rupture of the intestine affords another striking illustration of the progress of surgery. Siegel has collected 532 cases in patients treated without operation and the mortality was 55.2 %. In 376 cases in which operation was done, the mortality was 51 %. This does not seem so great a triumph for surgery as might be expected, yet if these statistics are carefully gone over it becomes evident that the mortality is due to a cause which in the future can be obviated. Aggressive surgery can do much in these serious cases if operation is not postponed too late, as shown by Senn, and as for example:

Cases operated	first 4 hours, mortality	15.2 %
" "	5 to 8 hours, mortality	44.4 %
" "	9 to 12 " "	63.6 %
" "	later	70.7 %

Rupture of the stomach has been cured by laparotomy; thus Petry found 44.5 % of recoveries in 18 patients operated upon within 24 hours after the injury, and 25 % of recoveries in 24 patients operated upon more than 24 hours after rupture.

Gangrene of the intestine forms an indication for resection of a segment of the intestine and offers a prospect of recovery in a class of cases otherwise fatal. Thus Roswell Park resected 8 ft. 9 in. of bowel for the relief of a gangrenous condition and the patient recovered. The same surgeon assembled from surgical literature 16 additional cases in which over 200 cm. of bowel were resected with 14 recoveries, or 80 % of cures, or a mortality of 17 %. A singular fact recorded by Park is that when from 100 cm. to 200 cm. was removed, the mortality was 30 %.

Subphrenic abscess is another serious condition which terminates, as a rule, fatally; but in which surgical intervention has been followed in a certain percentage of cases, thus Maydl records 74 operations with 39 recoveries, and 35 deaths, or a mortality of 47.2 %.

Ovariotomy forms a new milestone in the march of surgery. In all probability the most important surgical event that has ever happened in this country and the world, was the conception, birth, and development of ovariotomy. To Dr. Ephraim McDowell of Danville, Ky., belongs this great honor. In 1809 he was the first one to perform this unique and original operation which has made his name immortal. The far-reaching influences that have proceeded from this step are incalculable. Dr. McDowell is to-day recognized as the originator of not only one of the greatest operations in surgery, but also as the author of an operation, the influence of which has made it possible to develop the present wide field of abdominal surgery. McDowell's work will live in the memory of thousands in this land, and will be honored the world over as long as time endures. In 1821 Dr. Nathan Smith performed ovariotomy in Connecticut, and without the knowledge that it had been performed by McDowell; Smith dropped the pedicle into the abdominal cavity and thus made a great advance in McDowell's operation. In 1823 Allan G. Smith also performed an ovariotomy in Kentucky, and David L. Rodgers in New York in 1829. All these cases of ovariotomy were successful.

It was seven years after this last American operation before ovariotomy was first performed in England, and nearly 15 years before ovariotomy was first performed in France. In 1870 T. Gaillard Thomas first devised and performed successfully a vaginal ovariotomy. In 1872 Dr. Davis, of Pennsylvania, performed successfully the same operation, followed in 1873 by Gilmore of Alabama, and in 1874 by Battey of Georgia, and later by Sims. In 1872 Battey performed his first oophorectomy, "with a view to establish at once the change of life for the effectual remedy of certain otherwise incurable maladies." This is an operation also of purely American origin, and has contributed much to the relief of human suffering. It has been urged that while to an American surgeon the credit is honestly due for the first performance of an ovariotomy, other nations have perfected the operation, and more credit is due to-day to other nations for the best results. Let us see how this statement accords with facts. In 1857 the question of ovariotomy was brought up for discussion at the French Academy of Medicine, and only one surgeon considered the operation as sometimes justifiable. Up to that time there had been in America 97 ovariotomies, with 34 % mortality; in Great Britain, 123 operations, with 43 % mortality; and in Germany, 47 operations, with 77 % mortality. American surgeons, therefore, not only obtained the best results up to that date, but no American surgeon to-day will concede that our results are inferior to those obtained by surgeons in any other country at the present time. Few men can realize the influence of McDowell's first ovariotomy upon the whole field of abdominal surgery. It is, indeed, a sublime thought to consider that a man was found with the courage of his convictions to do what no man had ever done, and to operate with the noise of an infuriated mob beneath his windows. This mob would have lynched him if the patient upon whom this first ovariotomy was performed had died. Having escaped the angry mob, he was pointed out as a murderer by his fellow colleagues, and was condemned by the highest scientific authorities in Europe. In America, therefore, under such circumstances and under such conditions, the birth of the greatest operation in surgery occurred — an operation which saves now the lives of millions of women. Keen asserts that "it is estimated that one million years are added every three years to the life of women in this country alone by a single operation of ovariotomy."

The disapproval of this great operation of McDowell's by the press, by the profession, and by the laity was pronounced. The *Medico-Chirurgical Review*, speaking of McDowell's achievement, says: "A back settlement of America, Kentucky, has beaten the Mother Country, nay, Europe itself, with all the boasted surgeons thereof, n the fearful and formidable operation of gastrotomy with extraction of diseased ovaries." All this vituperation was hurled at McDowell; but time, as the great arbiter, has demonstrated that what was said in sarcasm has become a transcendent and mighty truth. The noble character and the true grandeur of McDowell's nature, and his high and lofty ambitions, are illustrated by the fact that he had performed three successful ovariotomies, operations never before undertaken by man, without heralding the victories as triumphs of his personal ambition. In the early days of ovariotomy, McDowell, and Nathan Smith, the Atlees, Dunlap, Peaslee, Kimball, Sims, and Thomas established and brought to the front an operation against which the most bitter and scathing invectives were aimed. These great men, who have placed this operation upon a firm basis, deserve the gratitude of a nation, and of the world, since they have thrown a flood of light upon this dark region of surgery, which is now illuminated by the work of recent operators whose successes are simply miraculous.

Mayo Robson has contributed an article on the evolution of abdominal surgery, a part of which has reference to the results obtained in ovariotomy. He states that in Leeds Infirmary, in 1870–1871, no case was reported under abdominal surgery. In 1901, or 20 years later, there were performed in the Leeds Infirmary 569 abdominal sections. In reference to ovariotomy, he states that about 1870 ovarian tumors were considered a variety of dropsy, and tapping was resorted to as a means of transient alleviation. Thus, in 1870, in St. Bartholomew's Hospital, London, there were only 3 ovariotomies performed, with 100 % mortality. In Guy's Hospital, London, 5 ovariotomies, with 60 % mortality. In St. Thomas' Hospital, London, 1 ovariotomy, with 100 % mortality. In St. George's Hospital, London, 2 ovariotomies, with 100 % mortality. In 1875, ovariotomy had such unfavorable statistics that tapping was done to defer a radical operation. In 1875, in 12 cases of ovarian tumor, only 7 patients had an ovariotomy performed, and 5 died, thus giving a mortality of 71 %.

Now mark the contrast. In 1901, ovariotomy was performed 64 times, with 4 deaths, or a mortality of about 6 %. When it is considered that in these cases some were malignant, gangrenous, and suppurating cases, the story seems incredible. Mouillin reports, in 1901, 57 ovariotomies in the hospital for women, with no death. Richardson, of Boston, reports 93 consecutive ovariotomies without a death. Ovariotomy in the aged shows most remarkable results; thus Kelly has reported in his book over 100 ovariotomies in women who were over 70, and operated upon by 59 surgeons, with only 12 deaths. This is a triumph of surgery that Ephraim McDowell foreshadowed in his courageous work. Sutton collected, in 1896, 11 cases of ovariotomy in women over 80, with no deaths.

Ovariotomy during pregnancy has likewise a most astonishing record, since Williams in his book reports 142 cases collected by Orgler, with only a mortality of 2.77 %.

In 1902, in one London hospital there were 40 ovariotomies, with 1 death, or 2.5 % mortality, as contrasted with 100 % mortality about 1870. Thus in a quarter of a century the mortality has been reduced in one of the most formidable operations in surgery from 71 % to 6 %, and in exceptional series of cases even to 2.5 % mortality. It may be of interest to show the progress which surgery has made during the century in reference to the operation of ovariotomy, from 1809 to 1904.

In America —	McDowell ....1809, and later,	12	cases;	mortality,	66 %
	N. Smith........1821,	1	"	"	0 %
	A. G. Smith 1823,	1	"	"	0 %
	Several operators 1855,	21	"	"	70 %
	In America 1857,	97	"	"	34 %
	In England......1857,	123	"	"	43 %
	In Germany 1857,	47	"	"	77 %
	Hofmeier 1903,	200	"	"	4.5 %
	Hofmeier ....1903, last,	115	"	"	1.74 %

From the above table it appears that during the first quarter of the nineteenth century, according to the combined reports of McDowell and N. and A. G. Smith, the mortality in 14 cases of ovariotomy was 57 %. The combined English and American returns for 1855 and 1857 give an average mortality of 48 %. The most recent figures are by Hofmeier, for 1903, who returns a mortality of 1.74 %. If the earlier mortality prevailed at the present time, Hofmeier would have had 180 deaths in a total of 315 cases, instead of 11, which actually occurred.

Hysterectomy, or removal of the entire uterus, with or without the ovaries and tubes, affords a most striking illustration of the recent development of surgery. Hysterectomy shows brilliant results when performed for malignant disease; but the result of the operation when performed for malignant disease is the darkest chapter in the present status of surgery. Bigelow collected, in 1884, 359 cases of hysterectomy for fibroids of the uterus, with a mortality of 58 %. Kelly reports, in 1898, 100 cases of hysterectomy, including extirpation of the ovaries and tubes, with a mortality of only 4 %. Pryor has investigated the subject of the mortality of abdominal hysterectomy for myofibroma of the uterus, and states that it is not over 2 %, while in fibrocysts of the uterus, it is much higher, reaching at least 10 %, and states that this great increase in mortality is due to "coexisting cardiac lesions, which so often accompany fibrocystic disease." Pryor also states that his mortality of hysterectomy in pus cases is about 3 %. Noble reports 58 cases of pyosalpinx and abscess of the ovary, in which he performs hysterectomy with removal of the appendages, and the immediate mortality was not quite 2 %, and 36 cases of removal of the appendages without hysterectomy, with a mortality of 5 %. Richardson, of Boston, had a mortality of 3 % in 111 cases during the past two years; and Polk, of New York, has had a long series of cases with equally brilliant results. Webster reports 65 hysterectomies for infective disease of the uterus and appendages, with a mortality of 1.07 %. With such an array of statistics before us in hysterectomy, which may be considered the keystone of the arch, there is no more forcible illustration of the steady advance of surgery than the improvement in this operation. In regard to vaginal hysterectomy, statistics are likewise brilliant; thus Pryor has collected 228 cases of vaginal hysterectomy for non-malignant disease, with one death. Webster reports 40 cases of vaginal hysterectomy for malignant disease of the uterus, with no death from the operation itself. No mention is made of the percentage of permanent cures in these cases.

Hysterectomy for the cure of cancer furnishes the most discouraging and melancholy statistics of any modern operation. In this case it is not so much the fault of the technic as it is the disease which calls for the operation. Cancer is most fatal in the uterus; but the time will soon come when early operations will effect a far greater percentage of recovery. Cancer of the cervix and body of the uterus is most fatal, yet the faintest glimmer of dawn is upon the horizon, and the results of hysterectomy for the permanent cure of cancer are beginning to show signs of improvement. In the history of every great operation the mortality is high at first; but as technic improves and early and radical operations are resorted to, the result will be different. Ovariotomy passed through just such a crisis, and it is certain that hysterectomy for cancer will show better results in the future and if so it will be the greatest triumph of surgery. The statistics of hysterectomy for cancer are subject to the widest variation. Penrose states that his results have been most discouraging, as he has only two or three patients who have permanently recovered. Penrose also criticises the report of 20 % of cures for cancer of the uterus at the Johns Hopkins Hospital, and claims that "after due deduction and thorough sifting of their figures, 5 % of cures comes nearer the actual truth." The mortality of the operation itself for the cure of cancer has a favorable showing in contrast to the results of permanent cure. Thus Pryor, in 1901, reports 98 cases of hysterectomy for cancer of the uterus with a primary mortality of about 11 %. In a very careful and thorough research of the literature of the subject, I find that abdominal hysterectomy for cancer has an immediate mortality of nearly 20 %, if the cases from all available operators are taken, and that the immediate mortality for vaginal hysterectomy for cancer has been as high as 16 %, and by some operators reduced to almost zero.

The Surgery of the Bones and Joints. The management of fractures has brought out the wonderful mechanical ingenuity which is a characteristic of the human mind. The application of the plaster-of-paris bandage in the treatment of fractures is one of the greatest improvements of the century. To the perfection of its technic, Fluhrer's work deserves special commendation. The use of flexible narrow strips of tin or zinc in the management of fractures was devised by Fluhrer in 1872, with the object of securing immobility of the fractured bones. The strips are not designed to act as rigid supports, although incidentally, by their width (a quarter of an inch) they edgewise oppose resistance to angular motion when passing through or near an axis of motion. Their principal effect is by virtue of their inextensibility, not shortening or lengthening under strain when bandaged to the limb in the principal planes of motion. They are roughened on each side by perforations, so that they may be securely held in position by the retaining bandage. They are not designed to serve as an accessory strengthening of an immovable splint; the strips themselves are the splint. The plaster-of-paris or other material incorporated in the retaining bandages gives to the provisional effect of the strips durability, which, of course, cannot be obtained by a simple bandage. The work of Dr. James L. Little, in the use of plaster-of-paris bandage, must not be overlooked, since he utilized this dressing for various fractures, and perfected several dressings for special fractures, notably the patella. Time will not permit of a discussion of the manifold ways that this dressing can be employed in the different fractures. It will suffice to mention the present method of treatment of fractures of the thigh, in order to afford the best illustration of the evolution of the general plan of the treatment of fractures. If we start with Desault's splint, which was crude and unsatisfactory, the first change that occurred was Physick's modification, which consisted in making Desault's splint, which reached only to the crest of the ilium, extend above to the axilla and downward below the foot, with a perineal band for extension and counter-extension. In 1819 Daniell of Georgia introduced the weight and pulley. In 1851 Buck still further modified Physick's splint, so as to do away with the perineal band, and accomplished extension of the limb by the weight and pulley, after the manner of its present use. This was a great improvement, in order to overcome shortening of a fractured limb.

Van Ingen, in 1857, suggested the elevation of the foot of the bed to permit the body to act as a counter-extending force. The coaptation splints were used by Buck, in 1861, so that the present complete and perfect method is one that is the result of evolution, the consummation of which has been accomplished by the work of American surgeons. In 1827 Nathan R. Smith adopted the principle of suspension in the treatment of fractures, and the use of the sand-bag was introduced by Hunt, of Philadelphia, in 1862. In fracture of the clavicle, Sayre has originated a dressing which is not only unique, but which is accepted as the simplest, most reliable, and most satisfactory of all the different forms of apparatus. Physick suggested the two angular splints for treating fracture of the lower end of the humerus, and Gunning and Bean the interdental splint in the treatment of the fracture of the lower jaw. Allis first called attention to the pathologic condition found in fractures of the lower end of the humerus, and suggested new principles in the treatment to prevent deformities. In 1861 Mason devised a new method of treating fractures of the nasal bones by passing a curved needle under the fragments and elevating them. In the treatment of fracture of the patella by the use of the metallic suture, American surgery can claim the operation as far as priority is concerned, since Rhea Barton wired a fractured patella in 1834, and McClellan, in 1838, and Cooper, of San Francisco, in 1861, and after him Logan and Gunn.

While American surgery cannot justly claim the priority of this operation as practiced by Lister with the modern aseptic technic, she can at least claim to having brought the operation to its present perfected technic, and can point to the fact that in New York the operation has been performed more times than it has been in any city, or in any country in the world. While the operation is not one to be recommended universally, it is an operation yielding brilliant results in suitable cases and in the hands of aseptic surgeons. The first time that fractures of the lower jaw were treated by metallic suture was by Kinloch of South Carolina. In the management of ununited fractures, American surgery stands preëminent. In 1802 Physick passed a seton between the ends of an ununited fracture of the humerus. In 1830, or twenty-eight years after the operation, Physick obtained the specimen. The use of the metallic suture was first successfully tried in 1827, by J. Kearney Rodgers, in a case of ununited fracture of the humerus.

Perforation of the ends of the bones in an ununited fracture of the tibia was accomplished in 1850 by Detmold. In 1825 Brainard introduced the operation of drilling the fragments. In 1857 Pancoast used the iron screw to accomplish the same object. In 1878 Pilcher first pointed out the correct pathology and the treatment of fractures of the lower end of the radius. Before dismissing the subject of fractures, the work of Hamilton and Stimson must not be overlooked, since they did more to systematize and to perfect the treatment of fractures in general than any other surgeons. The saw devised by Shrady for performing a subcutaneous section of the bone is an instrument worthy of the highest commendation. Excision of the superior maxillary bone, with the exception of the orbital plate, was first performed by Jameson, in 1820. The complete excision of the superior maxilla was first performed in New York, by David L. Rodgers, in 1824. Excision of the inferior maxilla was first partially and successfully made "without known precedent or professional counsel or aid," by Deadrich, of Tennessee, in 1810. Jameson exsected nearly the entire inferior maxilla in 1820. Mott exsected half of the jaw in 1821; Ackley in 1850; and Carnochan excised the entire bone in 1851. Excision of the os hyoides was performed for the first time by Warren, in 1803. Excision of the wedge-shaped piece of bone from the tibia and fibula, with osteoclasis of the bones, to correct a deformity by an osteotomy, was performed by Warren, in 1820. In 1835 Barton devised an operation which is still practiced for the relief of angular ankylosis of the knee. The entire clavicle was excised successfully for necrosis for the first time in 1813, by McCreary of Kentucky. The entire clavicle was again excised successfully for the first time for malignant disease, by Mott, in 1828. The entire scapula, three fourths of the clavicle, and the arm were excised for the first time, and also successfully, by Dixi Crosby, in 1836. This same operation was repeated by Twitchell, in 1838, by McClellan, in 1838, and by Mussey, in 1845, and since then to the present time the operation has been performed many times throughout the world.

The entire scapula and the clavicle were removed successfully six years after an amputation at the shoulder-joint by Mussey in 1837. Two thirds of the ulna was excised successfully by Butt, of Virginia, in 1825, and the olecranon by Buck, in 1842, while the entire ulna was excised by Carnochan, in 1853. The same operator excised the entire radius in 1854. Both radius and ulna were excised by Compton, of New Orleans, in 1853. Excision of the coccyx was first performed by Nott, in 1832, for the relief of severe and persistent neuralgia. Excision of a portion of the rib by the trephine, for affording drainage in empyema, was first performed by Stone, in 1862, and excision of a part of one or more ribs for the same purpose was first performed by Walter, of Pittsburg, in 1857. Beside these excisions for necrosis, suppuration, and malignant disease, much credit is due to American surgery for the part it has played in subperiosteal surgery. One of the most remarkable specimens is the reproduction of the inferior maxilla by Wood, in 1856. Langenbeck, the authority on subperiosteal surgery, said "that he did not believe a corresponding preparation really existed anywhere," and remarked that "there was not another such specimen in the whole of Europe." This was indeed a fitting tribute, from one of Europe's greatest surgeons, to the genius of one of America's greatest operators. Wood has also succeeded in reproducing many other bones in the body by the application of the same principles of subperiosteal surgery. Thus it is evident, if the first successful excision of the superior and inferior maxillas, the hyoid bone, the entire clavicle, the entire scapula, the ulna and radius, the coccyx and ribs; also trephining for relief of osteomyelitis; the most perfect specimens of reproduced bone, — be subtracted from the sum total of operative surgery upon the bones, there is little left that is not the offspring of American surgery.

In the surgery of the joints, American surgeons have accomplished brilliant work, since in the management of dislocations they have contributed much to the sum total of our knowledge. Physick was the first to perform venesection to cause muscular relaxation, in order to reduce a dislocation. This was a most valuable means, to which resort was made prior to the introduction of anesthetics. McKenzie and Smith, in 1805, reduced a dislocation of the shoulder of six months' standing by the employment of venesection. This patient had been to England and all attempts at reduction failed, and upon his return to Baltimore, the reduction was effected by relaxing the muscular system by blood-letting *ad delequium animi.* The plan is now abandoned since the introduction of anesthetics. Warren excised the head of the humerus to restore the usefulness of it after an unreduced dislocation of the shoulder-joint. The invention of plaster-of-paris jacket by Sayre, for the treatment of Pott's disease, in 1874, is one of the most important surgical discoveries of the century. The same apparatus he devised for the treatment of lateral curvature. These cases of Pott's disease, which hitherto were consigned to a distressing death, are now permanently relieved of their sufferings, and are in many cases entirely cured. Excision of the hip-joint was performed as a systematic operation, and successfully, for the first time in this country, by Sayre, in 1854. To this same surgeon is due the credit of suggesting and carrying into execution the principle of free drainage in cases of empyema of joints. In hydrops articuli, Martin, of Boston, in 1853, suggested equable uniform compression by means of an elastic bandage, and Sayre has applied the same principle by using compressed sponges. Martin, in 1877, also employed the elastic bandage for the cure of chronic ulcers of the leg. In 1826 Barton divided with a saw the great trochanter and the neck of the thigh to relieve ankylosis of the hip-joint. In 1830 Rodgers removed a disk of bone, and in 1862 Sayre perfected the operation and introduced a new principle by removing a plano-convex wedge of bone between the two trochanters, and made rotund the end of the lower fragment in order to form a new and artificial joint. In 1835 Barton removed a cuneiform wedge just above the condyle and fractured the bone, and made the limb straight to relieve angular ankylosis of the knee-joint. This operation is practically the osteotomy of the present time. In 1840 Carnochan first operated for the relief of ankylosis of the lower jaw by subcutaneously dividing the masseter muscle. In forcing open the mouth after tenotomy of the muscle, he accidentally fractured the bone, thus producing a false joint until the fracture united. Carnochan conceived then the idea of excising a wedge-shaped piece from the jaw and establishing a false joint. For the relief of this distressing condition, in 1873, Gross excised the condyle and a portion of the neck of the bone, and in 1875 Mears excised the coronoid and condyloid process together with the upper half of the ramus. Wood, in 1876, cured a patient with fracture of the cervical vertebra associated with paraplegia and brachial paralysis, by the use of the plaster-of-paris jacket. The patient, though completely paralyzed, made an excellent recovery and was able to resume his work as a carpenter.

Compound fracture may be designated as the touchstone of surgery, because a discussion of the treatment of compound fractures includes all the great principles involved in every department of the science. It embraces a consideration of cerebral, thoracic, and abdominal surgery; it includes a discussion of the great principles of antisepsis, it covers operative technic, it embraces the study of surgical pathology, it touches upon the higher departments of the science, and opens up the field where surgery must be considered, as an arena for the exercise of sound judgment, for the display of clear foresight, and for the exhibition of accurate knowledge and ripe erudition. Finally, a full discussion of this subject inevitably leads to a consideration of the progress of surgery during the present century and its precise status at the present day. In considering the management of compound fractures, I shall confine myself to the results of my own personal work as embodied in an extensive clinical experience embracing a report of 1000 cases, which I published some time ago, and since then hundreds more can be added to my list, with substantially the same result. These cases occurred within a period of a year in four metropolitan hospitals devoted to the treatment of acute surgical cases, and also in private practice. The accumulation of so vast an amount of clinical material has been attained with considerable labor. The conscientious treatment of these serious cases has been attended with a sense of great responsibility, and the results have been attained only by close attention to the minutest details in the management of each individual case. There are some points in the treatment of compound fractures that deserve special consideration, and it is only by a study of these cases in groups that clinical facts of essential importance can be established. The same plan of treatment has been carefully watched in many cases at the same time, and it has been by a process of evolution that some of the opinions which I shall enunciate have become fixed laws in routine practice. To see in one day nineteen compound fractures in the same ward with a normal temperature is not a coincidence. The number might possibly be, but the same condition in all is the result of the application of fixed principles which have been established as the result of long study and observation. To see at another time twelve cases in the same ward and all with a normal temperature is likewise no coincidence. These circumstances make it evident that the application of fixed rules is necessary to arrive at certain and uniform results.

The complete history of each one of the 1000 cases of compound fracture is carefully preserved. Each case is given in full, with the name of the patient, the date of his or her admittance to the hospital, the age, a description of the injury, the treatment in full, and the result, together with the name of the house surgeon on duty at the time as a matter of reference. It is obvious that time will not permit to discuss in detail these histories, and therefore I can only give a summary.

The general summary in the 1000 cases is as follows:

Skull	178
Nasal, malar, maxillas, and patellas	89
Arm	40
Forearm	41
Fingers and toes	97
Ilium, clavicle	2
Thigh	87
Leg	295
Fractures involving shoulder, elbow, or wrist-joints, as a result of disease or accident	39
Fractures involving hip, knee, or ankle-joints, as a result of disease or accident	85
Fractures involving carpal or metacarpal, tarsal or metatarsal joints, as a result of disease or accident	47
	1000

Now, following the example of surgical writers who have carefully tabulated the results of treatment in compound fractures, I shall eliminate all those cases in which primary amputations were performed, because they do not concern the point at issue; and I shall also, according to the practice of writers, reject all those patients who died of hemorrhage, collapse, shock, etc., within a few hours after injury. I shall also leave out cases of compound fractures of the hand and foot, as too insignificant to be classed with compound fractures of the long bones. After these deductions are made, there remain 681 cases of compound fractures, with one death due to sepsis. This gives a death-rate of about $\frac{1}{7}$ of 1 %.

In order to appreciate fully what aseptic surgery has accomplished in reference to the management of compound fractures, it is necessary to compare the results obtained prior to the introduction of antiseptic surgery. In the Pennsylvania Hospital, Norris has made a statistical report of the compound fractures treated between the years 1839 and 1851. During that time there were 116 cases of compound fractures of the leg and thigh (excluding those cases requiring amputation) with 51 deaths, thus giving a rate-mortality of 44 %. In the New York Hospital during the same period there were treated 126 cases of compound fracture of the leg and thigh (excluding those cases requiring amputation) with 61 deaths, thus giving a rate of mortality of 40 %. In the Obuchow Hospital reports of St. Petersburg there are 106 cases of compound fracture with a mortality of 68 %. In Guy's Hospital, from 1841 to 1861, there were reported 208 cases of compound fractures with 56 deaths, giving a mortality of about 28 %. Billroth reports from surgical clinics of Vienna and Zurich 180 cases of compound fractures (excluding cases of amputation), with a mortality of 31 % from septopyemia. Now, after the introduction of antiseptics, a study of Billroth's table of compound fractures shows a reduction in the death-rate to about 3 %. The influence, therefore, of antiseptics has caused the death-rate to fall from 68 % to about 3 %. In my personal report of 1000 cases, the fractures of the extremities only are compared, as has been done in all of the above tables; there is no death from septopyemia, and thus the rate of mortality from blood-poisoning is now reduced from 68 % to zero. It may be said, therefore, that pyemia and septicemia, which formerly destroyed as many as 68 % of compound fractures, have been practically eliminated.

The science of surgery has at last demonstrated to the world that it has fairly met these demons of destruction, and that it has conquered them. Without doubt, the means of warfare have been found in the establishment of bacteriologic laboratories, for without these institutions the discoveries that affect the happiness and mortality of the human race could not have been made. For my own part, I remained a skeptic to the germ-theory of inflammation until the Carnegie Laboratory afforded me an opportunity to work out this great problem. The reduction of the death-rate from 68 %, which half a century ago was considered a brilliant achievement, and a result which was thought worthy of publication, to that of a cipher, represents what surgery has done for the amelioration of human suffering and the preservation of life. These statistics afford us the most startling and impressive lesson of what surgery has done. It has lessened suffering, it has annihilated pain, it has saved limbs, it has conquered sepsis, it has saved life. Surely nothing could be added to show more clearly the triumphant march of the onward progress of the grandest profession in the world.

Compound fractures of the skull require surgical interference which formerly was not resorted to unless in extreme cases. The intervention of operative measures has not only reduced the mortality to a very small percentage by preventing an infective process, but it also has eliminated the various nervous phenomena, such as headache, ataxia, epilepsy, insanity, and other like conditions. I have treated many hundred cases of compound fractures of the skull, and at one time collected a series of 116 cases of my own, a reference to which may give an idea of what modern surgery has achieved in the past few years in the management of this class of serious cases. Of these 116 cases of compound fractures of the skull, excluding those deaths from shock within 48 hours, in accordance with all statisticians, because these deaths were not the result of any special plan of treatment, there are two deaths which may be ascribed to sepsis. Perfection has been almost reached in the technic of the operation of trephining; but as yet there are circumstances which are not controlled by the practical surgeon, and in the study of these causes future scientific surgery must be employed. In these 116 cases of compound fractures of the skull, there were two deaths due to sepsis, which give a mortality of less than 5%.

Traumatism of the vertebral column and the spinal cord have been treated by Sayre's plaster-of-paris jacket. The utter helplessness, the intense suffering, the absolute hopelessness, the wretched discomfort, the living death make these patients objects of pity to all under whose care they come. On the other hand, the recent advances in the science of neurology, the precision of topographic anatomy, the modern researches in physiology, the introduction of anesthetics and antiseptics, the wonderful inventions in mechanical art present a most vivid picture to the modern surgeon of what surgery has accomplished by this new method of treatment. The expectant plan terminates in death, the application of well-recognized surgical principle to this peculiar class of hitherto neglected cases, has demonstrated the possibility of salvation in at least a limited number. The treatment of all these different varieties of traumatism of the spine and cord by the plaster-of-paris jacket has met with brilliant results. Before the employment of the jacket, these patients were doomed to unalleviated suffering and death. There is no reason why the same brilliant results should not follow the application of the jacket when used in connection with spinal meningitis or myelitis secondary to traumatism. Some time ago I collected thirty-three cases of recovery after unmistakable fracture of the spine, and to this list many others an be added of recent date. Cases have been eliminated in which improvement only was noted. This list is sufficiently large to attract the attention of surgeons and to induce them to employ this method of treatment in all forms of traumatism of the spine and cord. Still again, the usefulness of the jacket is demonstrated in a large list of injuries, among which may be mentioned sprains, concussion, hemorrhage, lacerations, and inflammatory thickenings. Thus it is evident that immediate extension and counter-extension with immobilization by means of the jacket, in all forms of spinal injuries, offers the most satisfactory plan of treatment that has been suggested, a plan of treatment, too, in which the results show manifest evidence of improvement, and further a plan of treatment that has been attended with a most gratifying success.

Orthopedic surgery is a department by itself, a part of which will be discussed under pediatrics. Under orthopedic surgery there are, however, a few operations that could be referred to briefly in order not to overlook the importance of the subject. Orthopedic surgery literally refers to the treatment of deformities; but the progress in this department has already passed beyond the limits that originally were set for it, and include now some of the operations in general surgery. Among the advances mentioned by Taylor are the Lorenz bloodless method of manual replacement of congenitally dislocated hips, the correction of deformed limbs by forcible movement without division of the tendons, the straightening of the kyphotic spine by great force, as suggested by Calot, the use of Sayre's plaster-of-paris jacket for correction of Pott's disease, the straightening of deformities in the limbs by osteotomy, the correction of deformities affecting the long bones by osteoclasis, the arrest of disease of the joints by excision, the removal of osteomyelitic foci in bone by excision or by the Röntgen rays, tendon grafting suggested by Dr. Vulpius, nerve suture for transference of functional activity from a healthy nerve to a paralyzed nerve, the tuberculin injection from diagnostic purposes, the extirpation of articular disease, the cure of periarticular bursitis and tenosynovitis, the healing of non-tuberculous joint disease where the etiology is dependent upon microörganisms such as are found in typhoid, pneumonia, gonorrhea, syphilis, and septic infection; the management of atrophic and hypertrophic joint disease by improvement in the physical condition and correction by mechanical means, and finally the treatment of Paget's disease of the joints, or osteitis deformans.

Surgery of the Vascular System. In the surgery of the vascular system American operators have made most valuable contributions. The innominate artery was ligated for the first time in the history of surgery by Valentine Mott, of this city, on May 11, 1818. The operation was performed for the cure of aneurism, and the patient died. The operation was essayed for the second time by Hall, of Baltimore, in 1830, and again by Cooper, of San Francisco, in 1859. Both of these cases terminated fatally. The artery was finally tied successfully for the first time by Smyth, of New Orleans, on May 9, 1864. This last operator tied also the vertebral in the same patient for the first time. Thus it is evident that the ligature of the innominate artery was first performed in this country, and it was first ligated successfully in America. Mott tied 138 large arteries for the relief of aneurism, and no surgeon in the world ever has ligated so many vessels. The primitive carotid artery was ligated for the first time successfully, for primary hemorrhage, by Cogswell, of Hartford, on November 4, 1803. Abernethy is accredited with tying the primitive carotid first in 1798, but his patient died. The first successful case, therefore, of ligature of the primitive carotid for primary hemorrhage was in America, and Cogswell had no knowledge of Abernethy's unsuccessful attempt. Again the primitive carotid was first tied successfully for secondary hemorrhage by Amos Twitchell, of Keene, N. H., in 1807, eight months prior to Sir Astley Cooper's famous case, which was supposed until lately to be the first on record. The primitive carotid was first tied in its continuity successfully, for the cure of aneurism, by J. Wright Post, on January 9, 1813. This same surgeon repeated the operation successfully on November 28, 1816. The two primitive carotids were first tied in their continuity successfully, within a month's interval, by Macgill, of Maryland, in 1823. Mott tied both carotids simultaneously in 1833, for malignant disease of the parotid gland. In 1823 Davidge first tied the carotid artery for fungus tumor of the antrum. The primitive and internal carotids were first tied simultaneously by Gordon Buck, of New York City, in 1857, and again by Briggs, of Nashville, in 1871. The internal carotid was tied successfully above and below, for secondary hemorrhage, by Sands, in 1874. Carnochan tied both carotids for the first time for elephantiasis arabum of the neck and face, in 1867. The subclavian artery in its third portion was first tied successfully, for the cure of aneurism, by J. Wright Post, of New York City, in September, 1817. The subclavian artery in its first portion was ligated for the first time by J. Kearney Rodgers in 1845. The patient died and the vessel has never been tied successfully until 1892, when it was tied by Halsted, of Baltimore. The operation was for the cure of aneurism, and the sac was dissected out by removal of the clavicle.

This is the only case in which ligation of the subclavian on its tracheal side has ever been successful, although it has been attempted in other countries; but the vessel has never been tied successfully, except in this country. The primitive iliac artery was first tied in America by Gibson, of Baltimore, in 1812. The ligation was for the arrest of hemorrhage following a gunshot wound. The patient died on the thirteenth day. Valentine Mott tied the artery successfully for the cure of aneurism, on March 15, 1827. In 1880 Sands first tied the primitive iliac, by performing first a laparotomy and securing the vessel by this procedure. The internal iliac was first successfully tied for the cure of an aneurism by Stevens, in 1812, and again successfully by Mott, in 1827, and by White, in 1847. The two internal iliacs were first tied simultaneously for the cure of double gluteal aneurism by Dennis, in 1886, upon a patient belonging to Dr. Carpenter, of Boonton. In this case a laparotomy was performed as a preliminary step. The same operator has since tied successfully the internal iliac for the cure of gluteal aneurism, for the first time, by laparotomy, as a preliminary step to operation. The external iliac was tied successfully in 1811, by Dorsey, and again successfully by Post, in 1814. Onderdonk, in 1813, tied the femoral artery successfully for acute phlegmonous inflammation of the knee-joint, and Rodger did the same operation with success in 1824. Carnochan, in the year of 1851, tied the femoral artery for the first time for the cure of elephantiasis arabum, thereby inaugurating a new principle of treatment. In addition to the various ligations already mentioned for the cure of aneurism, the invention of a variety of compression, known as digital pressure, was carried into practice by Jonathan Knight, of New Haven, in 1848.

There are many modifications of digital pressure. Wood utilized the bag of shot which was suspended above the patient, and by this means the pressure was effected by it instead of by the finger. In 1874 Stone of New Orleans first cured a traumatic aneurism of the second portion of the subclavian artery by digital pressure upon the third portion of the vessel. Martin, in 1877, suggested the use of the elastic bandage in the treatment of varicose veins, and recently Phelps, the method of the multiple ligature of the veins from the ankle to the saphenous opening. He applies some 60 ligatures to the limb, and the results of his operations have been most satisfactory.

There has been much diversity of opinion as to whom the credit belongs for the introduction of the Esmarch bandage. In the public clinics of the Jefferson Medical College, at the time of an amputation, the limb was rendered bloodless by elevation of it, and by the application of a roller bandage to it by the elder Pancoast and Gross. This was done before a tourniquet was applied. The value of this procedure was not published, and to Esmarch is due the credit of having adopted the principle with the modification of the elastic bandage, and having published it abroad for the benefit of the profession.

In the surgery of the nerves the work performed by Americans is most commendable. In 1856 Carnochan excised the second branch of the fifth cranial nerve beyond Meckel's ganglion for the relief of tic douloureux, and two years later Pancoast performed the same operation in the pterygomaxillary fossa. The mortality of the Kraus-Hartley operation for the relief of tic douloureux by removal of the gasserian ganglion in 108 cases collected by Tiffany was 22.2 %. In a later series collected by Murphy the mortality of the operation was reduced to 16 %. The recurrence of pain after the operation is observed in about 10 % of the cases. This operation is one of the most beneficent ones in surgery, as it has afforded relief from the most excruciating pain and suffering.

In 1863 Gross removed the inferior maxillary branch of the same nerve. In 1871 Sands excised a piece of the brachial plexus for the relief of persistent neuralgia of a traumatic origin. Gross for the first time excised nearly two inches of the spinal accessory nerve. The sutures of nerves, even three days after division, have been united with restoration of the function of the nerve. Operation for the relief of facial paralysis marks a new epoch in surgery of the nerves. There have been 12 cases of facial paralysis reported by Faure. In these cases the paralyzed facial nerve was exposed by dissection and then united to the hypoglossal or the eleventh nerve, and through this inosculation, motor stimulus was given to the facial, which had lost its function. The results have been most satisfactory, even though the face had been paralyzed from five months to three years.

Amputation shows a steady improvement in its results during the past century. In this department of surgery American surgeons have not only taken the initiative in the more important amputations, but they have perfected methods devised by eminent surgeons in other countries throughout the entire world. The first successful primary amputation at the hip-joint was performed by a Kentucky surgeon named Brashear, in 1806. The amputation was repeated with success by Mott, in 1824. Nathan Smith was among the first, if not the first, to successfully and systematically amputate at the knee-joint, in 1824, and the technic of this operation has been perfected by Markoe and Stephen Smith. The first successful amputation of the ankle-joint in any country was performed in 1842, by Syme, in Scotland. Triple simultaneous amputations have been performed successfully, also quadruple amputation. These are among the curiosities of surgery, and illustrate the preservation of human life in the face of the greatest danger.

In the invention of prothetic apparatus the ingenuity of the American mind has discovered a most wonderful field of operation, since in no country can be found the mechanism that is displayed in the manufacture of aluminium artificial limbs. I have at present patients who can walk and even run with two artificial limbs, and one who has artificial hands who is employed as a pharmacist.

Staphylorrhaphy was performed by Warren, in 1820, the same year, it is just to state, that the operation was performed in France by Roux, but Warren had no knowledge of Roux's method.

Excision of the tonsil was an operation placed upon a permanent and safe basis by Dr. Cox, of New York. This surgeon invented, in

1820, an instrument which included the tonsil in a ring, and then cut it by a ring-shaped knife. The guillotine principle applied to the tonsillotome was an improvement upon this instrument.

The operation for the relief of goiter is a great advance in operative work, since this was formerly one of the most serious operations in surgery. Wölfer reports 60 cases collected from Billroth, Socin, and his own clinics with only two deaths. Reverdin's mortality was only 2.8 %, Kocher's results are most brilliant, 0.2 %. Mikulicz's, 2.6 %. The treatment of cretinism and myxedema by thyroid extract is another method of cure that has been followed by recent success in a fair percentage of cases, though the use of the drug must be continued for at least two years.

The operation for rhinoplasty to restore a lost nose is one of the triumphs of the century, and plastic operations for the restoration of a partially destroyed nose is also a contribution of modern surgery. *Cheiloplasty*, or the formation of a new lip, is another plastic operation, the product of aseptic surgery. *Stomatoplasty*, or the repair of defects of the lips from contraction due to burns, and *metoplasty*, or the repair of defects of the cheeks, and *blepharoplasty*, the repair of defects of the eyelids, are illustrations of the beneficent work that surgery has achieved.

Surgery of the Genito-urinary System. In the department of genito-urinary surgery a great advance has been made by the invention of instruments to facilitate and improve the technic.

The cystoscope is an American instrument, having been invented by Fisher, of Boston, in 1824, Civiale and Heurteloup having invented their instruments in 1827. The cystoscope of to-day is one which has been evolved from the general principle of Fisher's endoscope. Otis has perfected the urethroscope by the addition of a new lamp for the electro-urethroscope. Klotz has also devised a cystoscope which is in use at the present time. Brown has devised a most useful urethral speculum for the purpose of making topical application to the canal. The Gross urethrotome, also Powell's urethral dilator, and the Otis dilating urethrotome, and the urethrotometer are instruments deserving of worthy mention. The work of Bumstead and of Van Buren in this department of surgery have already world-wide reputation. The operation of nephrectomy for the relief of malignant disease of the kidney is of American origin, since it was first performed by Wolcott, of Milwaukee, in 1860. British surgeons give the credit of this operation to Simon of Heidelberg; but he did not perform his operation until 1869, or nine years after Wolcott's operation.

Nephrectomy was first performed in America for gunshot wound of the kidney by Keen in 1887, and again two months later for the same reason by Willard, and still again for the same cause by Price, successfully, in 1888. The first successful operation for the relief of extroversion of the bladder was performed in New York by Carroll on April 13, 1858. Pancoast performed the same operation successfully the same year, and Ayres in 1859. All of these cases antedate the British successes of Woods and Holmes, although there are two operative failures reported by Crook and Lloyd in London in 1851. In plastic surgery of the urethra another brilliant triumph has been made by American surgeons. In 1892 Alexander succeeded for the first time in the history of genito-urinary surgery in making a new urethra, the retentive powers of which were perfect in a case of complete epispadias in the female. There have been 12 cases in all of complete epispadias, in none of which heretofore has the urine been completely under the control of the patient. Physick did an internal urethrotomy by a concealed lancet, and Stevens, in 1817, was the first surgeon in this country to perform external perineal urethrotomy. He revived the operation, which had fallen into desuetude, since at the close of the last century the mortality was so great that the operation was practically abandoned. Prior to 1840 the operation was performed in this country by several surgeons; notably, in 1820 by Jameson, in 1823 by Rodgers, in 1829 by Warren, and later by several surgeons connected with the New York Hospital, among whom may be mentioned Hoffman, Post, Watson, and also by Alden March, of Albany, and Wood, of New York City. Without doubt the operation has reached its present state of perfection through the labors of Gouley, who suggested the whalebone guide, the tunneled catheter staff, and the beaked bistoury.

Hypertrophy of the prostate is a distressing and fatal condition which modern surgery in the course of its development has to a certain extent relieved, if not cured, in a large percentage of cases. It is one of the triumphs of the art within the period of time of which an inventory of the present surgical operations is taken. A review of the operation for the relief of hypertrophy of the prostate would be incomplete without an acknowledgment of the work of Reginald Harrison, Alexander, and White. As regards the benefits which have accrued to these sufferers from castration, it may be stated that White has shown that 66 % or more have return of the power of micturition, most of them a relief of the cystitis, and nearly all freedom from pain. In a series of 98 cases with 7 deaths estimated by White, the mortality of the operation was only about 7 %. This is after eliminating a few deaths which had no relation to the operation itself. These figures are striking, and as the time goes on and diagnosis is improved and technic is perfected, and early operations are resorted to, the percentage of alleviation of symptoms and of mortality will be even better than those just mentioned. Castration will never take the place of modern prostatectomy with its present low mortality, and which is gradually improving each year from about 6 % as reported by Mayo.

The operation for suprapubic prostatectomy was first performed in this country by Belfield, in October, 1886. Prostatectomy is an operation, the technic of which has been devised in recent years, and it gives great comfort to the patient and saves life. Murphy has reported 34 consecutive cases without a single death due to the operation. This operation has been greatly improved upon by the use of Gouley's prostatectome, which facilitates the removal of the gland.

In lithotomy American surgeons have achieved brilliant results. McDowell did 32 lithotomies in succession without a death. Dudley performed over 100 consecutive operations without a fatal case. In 1846 Willard Parker removed a calculus from the bladder by producting a rectovesical fistula; and subsequently performed this operation for the cure of chronic cystitis, and in 1861 Bozeman did this same operation to relieve a chronic cystitis in the female. In 1836 Physick removed over 1000 calculi. These brilliant results in lithotomy are most remarkable when it is considered that there was a time in the medical history of this country when a patient actually made the pilgrimage across the ocean in order to secure the services of a surgeon to perform lithotomy.

Litholapaxy is an operation that was introduced by Bigelow in 1878, and has been the means of saving thousands of human lives within the past quarter of a century. It forms one of the most prominent advances in surgery that has distinguished the century. By litholapaxy is meant the crushing of a stone in the bladder with an instrument called a lithotrite and the immediate rapid evacuation of the fragments from the bladder by a syringe especially made and adapted for this purpose. It is a matter of surprise and interest that Bigelow's entire apparatus for litholapaxy remains essentially the same to-day as it did a quarter of a century ago, which demonstrates how complete the mechanism is in all its minor details. Keyes has made some great improvements in litholapaxy, thereby reducing the mortality of the operation, among which may be mentioned in the list of improved instruments the modern evacuating-tube, the alteration in the mechanism, and other improvements in the technic of the operation. Keegan performed Bigelow's operation 59 times in children, with one death, and Freyer performed it 49 times without a death. The record of Bigelow's, or the American operation of litholapaxy, has certainly won for itself a fixed place in the annals of surgery.

Rupture of the bladder was operated upon successfully by a laparotomy by Walters, of Pittsburg, in 1862, but to Sir William MacCormack is justly due the credit of establishing this operation.

Rupture of the bladder has been successfully treated by modern surgery. Formerly these patients nearly all died; thus Ullman's statistics show only 22 recoveries in 237 cases, and in 143 intraperitoneal ruptures only two patients recovered. If the patients are operated upon early and with aseptic precaution, the prognosis is as brilliant as it was formerly forlorn.

Tumors of the bladder have been removed in recent years, and this operation marks an important epoch in this department of surgery. In benign tumors the mortality is about 10 %, while in malignant tumors the mortality is 25 %. These statistics are certain to improve in the future. Intravesical cauterization with the operating cystoscope for small tumors of the bladder has met brilliant results; thus Nitze had 119 cases without a death.

In surgery of the kidney great progress has been made. The floating kidney is successfully anchored, gunshot wounds of the kidney cured, renal calculi removed, suppuration in the pelvis of the kidney arrested, removal of the kidney itself undertaken for tuberculous and other diseases, and tumors of the organ excised. These are among the achievements of modern surgery, to relieve conditions which were uniformly fatal in pre-anesthetic and pre-antiseptic days.

Nephrotomy for the extraction of calculi has been performed and in aseptic cases has a mortality of only 2.9 %. If infection is present the mortality reaches 23 %. If nephrectomies for the past ten years are taken, irrespective of the disease for which the operation is performed, surgery has obtained a great victory, since in 365 cases of lumbar nephrectomies there was a mortality of 17 %, and in 165 cases of abdominal nephrectomies there was a mortality of 19 %. These figures indicate what surgery has accomplished in cases heretofore fatal.

Nephrectomy for the relief of tuberculous kidney marks a great advance in surgery of recent years. Statistics show that in 22 nephrectomies, 16 patients recovered, or about 70 %. In another group the recoveries were from 12 % to 33 %.

Aneurism of the renal artery has been operated upon by Albert, Hahn, and Keen, and all of their patients recovered.

Wounds of the ureters have been successfully sutured, a triumph of modern surgery, and the ureter itself catheterized for diagnostic purposes.

Malignant tumors have been treated with brilliant success in recent years. In fact, so much so in certain varieties that the term seems almost a misnomer. In the management of malignant tumors, American surgeons have displayed great ability. The early work of Warren, of Boston, was among the first attempts systematically to collect and study neoplasms from a clinical point of view. The writings of Gross upon tumors demand more than a passing notice, while the contributions of Shrady and of Mudd to cancer of the tongue are most exhaustive.

Malignant tumors are now often cured by radical operations. A century ago these cases presented a frightful mortality. In the course of the development of surgery, owing to anesthesia and antiseptics, more radical operations are permissible, and cures are now effected where formerly death was the inevitable result. The study of sarcoma is fraught with great interest on account of the meager knowledge, and of its great importance owing to the fact of the terrible mortality which attends the disease. Sarcoma of bone inevitably terminates in death, and its early recognition and its complete removal are subjects which are worthy the profound study of the surgeon. Sarcoma, in the large majority of cases, is a disease more deadly in its nature than any other variety of malignant tumor. Its unprecedented rapidity of growth, its widespread metastases, its insidious development, its uncertainty of early diagnosis, its absolute certainty to kill, make this disease a subject of paramount importance. In this address a study of the varieties, the etiology, and the diagnosis has no place. The prognosis concerns us only.

The prognosis in sarcoma is as gloomy as can be imagined. It is a disease which destroys life rapidly unless arrested by amputation. The prognosis may be modified as regards time by the situation and the particular cell variety of the sarcoma. In whatever way we look at the prognosis it is serious. On the other hand a radical amputation may rescue a patient's life, even in the cases of the most malignant variety. I shall refer to some statistics already published by others, and present the result of my own personal work, as evidence of the progress which surgery has made within the past quarter of a century. For purposes of illustration the malignant tumor known as sarcoma will be first considered.

Sarcoma of glands is a malignant tumor concerning which reliable statistics are very meager. The great English authority, Butlin, states that he fails to discover a single case of permanent recovery after operation. In my list there have been 12 cases of sarcoma of the glands up to 1895, the subsequent histories of which are all known. There have been some cases since that date; but sufficient time has not elapsed since operation in some of the cases, and unreliable histories in some other cases, prevent the tabulation of these cases subsequent to 1895. The principle of cure is the essential feature, and the data up to 1895 have been most carefully investigated. This may be said of all the cases of sarcoma. In these 12 cases, recovery occurred in every case but one, thus giving 83.3 % of permanent cures beyond the three-year limit of time. In these 11 successful and permanently cured cases of sarcoma of the glands, there were some which were very large. In two the tumors involved the neck, one of which was larger than a child's head, necessitating a deep and dangerous dissection, which exposed the large cervical vessels. In another case the tumor was situated about the femoral vessels. Some of the tumors were removed in the presence of alarming hemorrhage and involved a most formidable operation. Thus, in sarcoma of glands with 100 % mortality, the permanent cure amounted to 83.3 % in the 12 cases.

Sarcoma of bone in previous years has been attended with a frightful mortality until surgery, with modern technic, has come to the rescue of these unfortunate sufferers. Butlin records 78 cases of subperiosteal sarcoma, of which the results in 28 cases were unknown, and in 6 cases more the patients had not reached the three-year limit of time, which leaves 44 cases in which the full subsequent histories are known. Of these 44 cases, 14 died of the operation and 29 from recurrences, which leaves but 1 permanent cure in the 44 cases. There are thus 78 cases in which the operation was performed; 14 of the patients died from the immediate effects of the operation, which gives 18 % mortality for the operation itself, and of the 44 patients whose full subsequent histories are known, there was but 1 permanent cure, or 2 %. In my list I reported 21 cases of subperiosteal sarcoma of bone in which an operation was performed, 1 of which was an amputation of the hip-joint, and the patient died from the immediate effects of the operation. This gives only 5 % mortality for the operation itself. The histories of 4 are unknown. In the remaining 17 cases of the original 21 cases in which the results are known, there are 3 deaths, 1 of which has just been referred to as a result of shock, and 14 cures beyond the three-year limit of time, which gives 82 % of permanent cures. This is in marked contrast to Butlin's statistics, which records only 2 % of permanent cures.

Sarcoma of the breast is a disease that formerly was most fatal. Modern surgery has accomplished much in reducing the terrible death-rate. Butlin, in his book on malignant disease, gives no results either as to mortality or as to permanent recoveries. Williams, in his book, reports 10 cases of sarcoma of the breast, in which no deaths occurred in consequence of the operation itself. The subsequent histories of only 2 out of the 10 cases are known. Death occurred in the 2 cases within 2 years from the date of the operation. The percentage of permanent cures, therefore, amounts to zero, since no patient recovered so as to be free from the disease for a period of 3 years. It is to be regretted that nothing is known of the 8 cases since among the list; there may be some cases of permanent cure. It is unfortunate that these cases have been lost sight of, since no statistics of permanent cure can be recovered unless the result is known. Gross reports 91 cases operated upon, of which 12 were permanently cured, giving 13 % of permanent cures.

I operated in 6 cases of sarcoma of the breast, in which no death occurred in consequence of the operation itself. The subsequent histories are all known. Four of the 6 patients were permanently cured, and the remaining 2 died from a return of the disease. This gives 62⅔ % of permanent cures in sarcoma of the breast.

Carcinoma of the breast affords a striking illustration of a disease over which surgery has gained a decided victory. There is no more brilliant example to show the progress of surgery during the past century than is found in a study of cancer of the female breast. The necessity of an investigation of carcinoma of the breast can be estimated when it is considered that in England alone there are 7000 deaths annually from carcinoma, and that there are 30,000 patients suffering at all times in that country from this affection, of which number a large proportion involve the breast. When it is considered that 50 % of the cases of carcinoma of the breast die within three years, and that a third die within two years, and that of all of the tumors affecting the breast, 80 % consist of carcinoma, some idea can be formed of the overwhelming interest and paramount importance of this subject. The mere fact that carcinoma causes more deaths in the United States in one year than the sum total of deaths due to erysipelas, tetanus, hydrophobia, lighting, typhlitis, gunshot wounds, joint disease, together with well-known surgical affections, conveys at once an idea of the wide dimensions of this subject. Carcinoma causes nearly half as many deaths in a year in the United States as are caused by accidents and injuries of all kinds and descriptions.

Dr. Billings has demonstrated by statistics that carcinoma is a disease which is slowly increasing, and that it is a cause of a larger proportion of deaths in nations which have reached the highest state of civilization. For example, in the United States in a year there were over 13,000 deaths from carcinoma, of which there were twice as many deaths among females as among males. There were 1387 cases of death from carcinoma of the breast alone in this country during the year 1880, and since then statistics show the disease is still increasing. The mortality of this disease, if left unoperated upon, is nearly 100 % at the present time, just as it has always been. The mortality of the patients operated upon formerly was considerable, and the percentage of permanent cures very small, while now the operative mortality is very small and the percentage of permanent cures is very high.

I shall refer to my own personal experience, the results of which I have already published, adding, however, that the results in the more recent cases are even better; but the data in full are not possible to collect for many reasons, and chief among these is the three-year limit of time. I have collected within a given period a series of

116 cases of tumors of the breast, 19 of which were not operated upon, leaving 97 cases in which the breast was amputated. In the 97 cases of amputation there was but one death, thus giving a mortality of a little over 1%. The one fatal case was due to the presence of hemophilia and is a death that might have occurred in connection with any other operation, no matter how insignificant in character. This death can therefore with propriety be excluded as far as bearing upon the mortality of this special operation, and if so, there is an unbroken series of 96 consecutive operations without a death. In addition to the reduction of the mortality of the operation from as high as 23 % recorded by Billroth to a zero, there was no case of pyemia, septicemia, or erysipelas of the 97 cases of amputation of the breast. Twenty-three cases of sarcoma and other tumors than cancer must be eliminated in order to compute the percentage of permanent cures of pure carcinoma of the breast. These cases of sarcoma of the breast are discussed in connection with the subject of sarcoma. Of the 74 cases of pure carcinoma of the breast, the subsequent histories of 41 are known. Three of these patients have not reached the three-year limit of time, although they are still alive and free from the disease; there remain 38 cases, therefore, of pure carcinoma of the breast in which the full subsequent histories are known. In these 38 cases there are 17 cases in which a permanent recovery has taken place. This gives 45 % of permanent cures. Among these 38 patients whose histories are known there were but 2 local recurrences, which gives but a little over 5 % of local recurrences. Since the publication of this series I have had 15 consecutive cases of pure carcinoma of the breast with no mortality from the operation itself. Of these 15 cases, 1 died several weeks following the operation from hemophilia, in which the major joints were filled with blood, and the greater part of the body was affected with subcutaneous hemorrhages. Two of the 15 have not yet reached the three-year limit of time. There are, therefore, 13 cases in which the full subsequent histories are known; 2 of these patients died from a recurrence of the disease and 1 from hemophilia, as stated before, and the remaining 10 have passed the three-year limit time. This gives 77 % of permanent cures in cancer of the breast in the last 15 consecutive cases. I believe the last 15 consecutive cases will yield even better results. At all events, the mortality was zero and the permanent cures seem likely to be higher than 77 %. Modern surgery has much of which to be proud in connection with amputation of the breast, since the frightful mortality of a century ago has been replaced by a steadily increasing percentage of permanent cures. In the future even the present favorable percentage of permanent cures will be increased as early and more radical operations are practiced.

In 1820 Sidney Smith, the great literary genius of his time, made use of the following phrases in the *Edinburgh Review*, which furnishes somewhat amusing reading in the light of to-day: "Americans have done absolutely nothing for the sciences. . . . In the four quarters of the globe, who reads an American book? What does the world yet owe to American physicians and surgeons? What new substances have their chemists discovered?" The contradiction of the first phrase that "Americans have done absolutely nothing for the sciences" is found in the brilliant and wonderful achievements performed by them, as recorded in this address, by which millions of human lives are saved. "In the four quarters of the globe, who reads an American book?" To such a challenge facts reply louder than words. Were you to take from the world's medical literature, alone, all that has been contributed by Americans during the past century, the result would be astonishing and the loss incalculable. "What does the world owe to American physicians and surgeons?" To this challenge the record of new operations, bold and undreamed of, the invention of new processes, the introduction of new instruments and methods, all of which I have endeavored to outline rapidly in this address, is the abundant reply to this unique interrogative viewed in the light of to-day. "What new substances have their chemists discovered?" The sufficient answer is, "anesthesia," which one discovery apart from all the other noteworthy ones which our chemists have made, places the civilized world under unspeakable obligations to America. Anesthesia is by far the greatest and most far-reaching discovery of the century, a gift to the world which cannot be estimated, a direct benediction from God upon mankind for the saving of life and the escape of humanity from pain.

In a review of the statistics that have been presented, one prominent fact stands out in clear and bold relief, and that is, that all along the line constant and marvelous improvement has been made in the science of surgery. To this statement there is not a single exception in the entire surgical domain. Everywhere and in every department there has been uninterrupted progress — a progress which has not been hindered or hampered by the loss of any past discovery.

In nearly all the other arts and sciences there is something which has been lost. They have advanced, indeed, most gloriously, and their present development is wonderful in the extreme; yet each one has dropped some good thing by the way which can never be recovered. Their votaries in bygone centuries possessed some secrets in methods and processes which not only died, but evidently were buried with them. By these they secured certain remarkable results which their modern followers, try as they may, are unable to reproduce. Thus in the art of painting, sculpture, architecture, mosaics, pottery, and physics, there are what we style "lost arts," as Wendell Phillips so eloquently has told us, contributions from which have come down to us from the past, which cannot be duplicated in the present. In painting, for instance, the superb coloring of the ancients in their Tyrian purple, and the brilliant scarlet which fades not in centuries. In sculpture, the majestic chiseling of Michael Angelo, that crumbles not in ages. In mosaics, the fusing of gold and glass so that the yellow of the precious metal retains its perfect color. In pottery, a variety of delicate tints and graceful forms which baffle the skill of the potter in these modern times. In physics, the pyramids of Egypt — how were the huge blocks of stone ever carried to the summit, some of them nearly 500 feet above the desert sands, to be laid there in courses which are absolute in regularity and evenness? How were the gigantic monoliths of Baalbec cut out of the mountains and set high in the walls of the Temple of the Sun? How were the mighty obelisks, 16 centuries B. C., transported from the distant quarries, and then set on end with perfect exactitude? Or how was the massive capital, weighing 2000 pounds, ever lifted to its place on the top of Pompey's Pillar, 100 feet in the air? All these are forcible illustrations of arts which have been been lost.

But in the science of surgery it is wholly different, and there is no such counterpart. No operation, no invention, no discovery in this domain that was worth the keeping has ever been lost. The truth is, surgery, as it is practiced nowadays, is so completely a modern science that it does not rely upon anything in the distant past for its present or future development. That distant past was dark with horrible things which may well be tumbled into oblivion. It is only a few decades ago that surgery emerged from the black period of ignorance and cruelty and took to itself a new face and another spirit and form. At once it began its onward march, which speedily became a triumphant one, difficulties giving way before it, obstacles being overcome, every step an advance, with here and there a milestone set up to mark some distinguished feature in the splendid progress. By this new science diseases, which were formerly attended by 100 % of mortality, are now accompanied by almost 100 % of recoveries. In fact there is no surgical disease whose mortality has not been reduced. No other science can show such brilliant achievements, and no other science can demonstrate its ability to save so many human lives or to ameliorate their condition. We live in an age that is marvelous for its discoveries and achievements, but in no department of science have greater changes been wrought or more brilliant results accomplished than in surgery. It would now seem that we had almost reached the goal. There are but few surgical diseases which our art in its present condition of development does not cure. There are but few operations in point of number that remain for succeeding generations to discover. There is still little to gain in the technic of asepsis and anesthesia, and beyond the improvement of existing operative methods there is but little to expect. The science of surgery has accomplished a great work — one of the greatest in the history of mankind. And when we consider the vast number of surgical diseases which are now amenable to cure, and the very limited number remaining for which the surgery of the future is to discover ways and means of treatment better than those to which we have already attained, we can realize that we stand on the heights of a great profession — a profession which but a century ago was crude, undeveloped, and uncertain. If there are higher heights to be reached in the science of surgery, and doubtless there are, we may rest assured that the vast and ever-increasing wealth of this great country will be utilized toward their attainment. Humanity demands this, and this country will never be behind any nation of the world in earnest efforts for the promotion and development of a science whose special aim is the relief of physical suffering, and the preservation of human life.

It is fitting on an occasion like this, when a national celebration is in progress, that the attention of this Congress should be directed to the part which our own country has played in the evolution of this great science. This part is best set forth and realized by a study of the facts recorded in this address. The question, however, as to what has been the inspiring motive, and what has been the controlling influence, must be sought in the life-history and habits of the people.

The impartiality and promptitude of the American mind have enabled it to seize with alacrity upon the best in every department of science and art, wherever found, regardless of the source from which it emanates. Accordingly, American surgeons all through the past century have busied themselves in reaping a generous harvest from every nation that had any good surgical idea, method, or appliance to offer, and have gathered in abundant sheaves with rejoicing, serenely indifferent as to the particular field which produced them. What mattered it to them whose hand sowed the seed, or under what influences it was brought to maturity, so long as the grain itself was desirable and could be secured for the American garner. A precisely opposite spirit has prevailed in some other lands; thus, during our colonial days, when Great Britain and France were easily foremost in surgical attainment, so bitter was their rivalry, so intense their national jealousy, that neither would adopt anything, no matter how good or valuable, which had originated with the other. Of late years this same prejudice, this un-willingness to indulge in a sensible reciprocity, has been manifest between France and Germany, to the great detriment of surgery in each of these rival countries. As an apt illustration, characteristic of the difference between the English and American spirit in this regard, may be cited the fact that in 1823 the writings of one of the great French surgeons, Desault, the most noteworthy contribution to the surgical literature of the world then published, had never been translated for the use of British surgeons. No Englishman had the courage or willingness to demean himself by so doing, since he would thereby acknowledge that some good thing might come out of France. Yet at that very time, Smith, of South Carolina, rejoicing as one who had found great spoil, was busily engaged in putting Desault's works into English for the benefit of the surgeons of America.

So in this great triangle of nations formed by England, France, and Germany, the surgical knowledge and suggestions of each remained within its own walled domain, untouched by the others; on the contrary, in a pleasantly independent spirit, and having no unfortunate jealousies to cherish, America reached her eager hand over the separating wall, and freely and gratefully laid hold upon whatever she considered best in the surgery of those and other nations, appropriating to her own use, for the good of humanity at large, as many of their principles, theories, discoveries, methods, and appliances as she considered it worth her while to take. Availing herself of these factors, utilizing them as stepping-stones, and combining them with the wonderful achievements of her own inventive genius and skill, she has rapidly risen to that illustrious height in the surgical world which she so grandly occupies to-day.

It goes without saying, gentlemen, that within the past decade, America, without any effort of her own, without the least self-seeking, but through the force of her national greatness — moral, intellectual, physical — has come to the front as a world-power among the nations of the earth. She now ranks second to none as an important and controlling factor in the congress of nations, and when she speaks, her voice commands the attention of a listening world. In this regard her science of surgery has kept even pace with her political advancement upon the powers. At the present time her surgeons are not outclassed by those of any other country, while in her contributions to the general literature of surgery, she stands unsurpassed. It is an actual fact, if you were to strike from the notable surgical achievements and writings of the world what has been contributed by America during the past few decades, there would be left but little of new and original work for the older nations to claim as their own.

There are many things which combine to explain the prominent position which America has taken during the past century in the consummation of this great work. Chief among them may be mentioned the innate courage which our Puritan ancestors possessed. The undaunted bravery which enabled the people of the Mayflower, and others of kindred heart and mind, to cross the great unknown oceans and to settle in the primeval forest for the sake of liberty, has infused itself into the American spirit and has qualified Americans to attempt and to perform daring deeds in surgery. There is no science that calls for greater fearlessness, courage, and nerve than that of surgery, none that demands more of self-reliance, principle, independence, and determination in the man. These were the characteristics which were chiefly conspicuous in the early settlers of this country. And it is these old-time Puritan qualities, which, descending to them in ordinary generation, have passed into the surgeons of America, giving them boldness in their art, and enabling them to win that success in surgery which now commands the admiration of the civilized world.

Permit me to sum up in a few words the wonderful achievements of surgery during the century which has gone. What has this great science, so young comparatively and yet so strongly and splendidly developed, accomplished in its onward march? Among the blessings which it has brought to the human race may be mentioned these:

The annihilation of pain during surgical operation.
The elimination of sepsis after operations and injuries.
The eradication of physical suffering.
The restoration of sight to the blind.
The recovery of hearing to the deaf.
The return of lost functions to organs and glands.
The aseptic repair of injured parts.
The relief of the crippled and lame.
The restitution of speech and consciousness.
The return of activity to paralyzed members.
The removal of malignant disease.
The restoration of reason to the insane.
The correction of bodily deformities.
The alleviation of pain in disease.
The reaction from shock and collapse.
The cure of lockjaw and other infective processes.
The intervention of relief in intestinal perforation.
The extirpation of tumors from glands and cavities.
The cure of diseases and injuries of internal organs.
The resection of diseased viscera.

The excision of joints and necrosed bone.
The amputation of diseased members.
The cure of aneurism.
The removal of cerebral and spinal neoplasms.
The reduction of mortality in all surgical diseases.
The entire removal of mortality in some surgical diseases.
The restoration of health and reason.
The salvation of human life.

Surely, Mr. President, and fellow members of the International Congress of the Arts and Science, the great science to which we have devoted our talents and our lives, the science which kindles our enthusiasm, and of whose achievement we are justly proud, our science of surgery during the past century has come as a benediction upon the human family, second to none which the century has spoken. Its benefits cannot be measured by words, or realized in thought. We are apt to speak of it as a human achievement. In one sense, so it is; but it is come in the orderings of an all-wise Providence; and with grateful hearts we acknowledge it as a gift and blessing from the Almighty Father to His suffering children in the world.

SHORT PAPERS

Dr. Carl Beck, Professor of Surgery in the New York Post-graduate Medical School, and Chairman of the Section of Surgery, presented an interesting technical paper "On the Technic of Urethral Dislocation in Hypospadias and in Other Defects and Injuries of the Urethra."

Professor Johannes Orth, of the University of Berlin, presented the following short paper on "The Morphology of Cancer and the Parasitic Etiology."

Gentlemen, — In answer to the request of your president, Dr. Carl Beck, I address you to-day concerning Carcinomatous tumors. I can tell you nothing new, but perhaps it will have a certain interest for you to hear the views of a pathologist who agrees in general with the greater number of German pathologists in regard to two questions which read:

I. What are the morphologic characteristics of cancer?

II. What is the present position of the question of its parasitic etiology?

I

As regards the first question there can be no doubt that the characteristic and determining elements are the cancer cells, and the cancer cells are nothing else than epithelial cells. They are epithelial cells not only as regards their structure but as regards the character of their protoplasm and their nuclei. Not only epithelial as regards their biologic activities, they are also epithelial as regards their origin.

There is no metaplasia of connective tissue, or other cells into epithelial cells, into cancer cells. Of course one sort of epithelium can change into another, cylinder cells into squamous epithelium, squamous cells into cylinder cells, but an epithelial cancer cell is never formed from a connective tissue cell.

In primary cancers the fact of the direct origin of cancer cells from preformed epithelium is, however, difficult to prove, as the growth of a cancer is not the same, nor is its primary origin. I, indeed, believe that there are cancers in which the conversion of preformed epithelial cells into cancer cells proceeds continuously in the surrounding tissues at the edge of the primary tumor, that there are multicentric cancers, not only in the sense that at the same time cancerous transformation occurs in numerous neighboring places, but also in the sense that one place becomes carcinomatous later than another. I realize, however, that many cancers are unicentric, that they originate from a single cell complex and possess only interstitial, no appositional growth. Previously we assumed without proof a cancerous transformation of preformed epithelium wherever epithelial and cancer cells came into contact. That such a view is not permissible has been justly pointed out by Ribbert; as it is possible that cancerous epithelium has grown against preformed epithelium and secondarily displaced this; but we cannot go so far as to explain the relation of cancer cells with normal epithelium which we find at the edge or in the immediate neighborhood of a cancer in this way, although we can often show positively in serial sections that an isolated growth of preformed cells occurs in which the quality of the cells show a certain variation from the appearance of the mother cells. That in such cases a special sort of karyomitosis occurs, similar to the mitosis of a fertilized ovum, I have not been able to convince myself, but without doubt changes in the behavior of the cells towards stains occur, as may be shown most easily in the cancers of the gastro-intestinal tract. Not every phenomenon of growth in preformed epithelium can, however, be looked upon as the beginning of cancerous transformation, for there occurs at the border and in the neighborhood of cancers and of other rapidly growing tumors, cell division, as well as glycogen formation, which are only the expression of purely hyperplastic processes, but when a distinct conical invasion of the underlying tissues, with transformation of the cell-body, can be demonstrated, we may well think of primary cancerous transformation.

The origin of cancer cells from preformed epithelium can, of course, be recognized most easily in very young cancers and Dr. Borrmann, Ribbert's assistant, who collected such cases and investigated them carefully did a great service. In his recently published work he brings proof of the epithelial origin of cancer cells in young primary cancers.

Secondary cancers of all sorts give especial support to the view that all cancer cells originate from epithelial cells in regular generation; because the numerous mitoses which cancer cells show let us see how rapidly they are divided; so rapidly that the entire growth of these secondary tumors may be completely explained in this way. The occurrence of the first cancer cells in the lymphsinus of the lymph glands, or the appearance of cancer cells in blood-vessels, shows us that metastatic cancer cells are the basis and starting-point of new cancer nodules. It can be shown most strikingly by study of serial sections of cancers of embolic origin in the lungs or the liver that cancerous growth in the neighborhood of the vessel always takes its origin from a cancerous penetration of the wall. There is no auto-infection through the uninjured vessel wall of the connective tissues surrounding the walls of the vessel, but a continuous connection between the embolus and the peri-vascular cancer; the embolus by increase of its cells has grown through the wall into the surrounding tissue.

The behavior of the parenchyma cells at the seat of the new tumor gives especial support to the view that all cells of the secondary cancer have arisen from displaced cells of a previously existing cancer. As we may show especially in cancers of the liver, the local cells, the liver cells, have absolutely nothing to do with the formation of cancer cells. They remain entirely passive, and are pushed aside by the uninterruptedly dividing cancer cells, they become atrophic and finally vanish completely.

All these facts show that the epithelial cells are the essential elements of cancer. But they are not only the essential but the *only* essential element. The tissue which in addition is present in cancers, stroma, has no bearing on the nature of cancer.

There are carcinomatous tumors without any stroma. In the so-called lymph vessel cancers, that is, the growth of cancer cells in the lumen of lymph vessels, as known in cancers of the lungs, of the uterus, and of other parts, extremely dilated lymph spaces can be filled, for long stretches, entirely by cancer cells without a trace of stroma being present. In other cancers the local tissue of the part may take the place of stroma. Thus there are cancerous growths in the lung in which the alveolar lung framework fills immediately the place of cancer stroma. Thus, in intro-vascular or infiltrating carcinoma of the liver, the liver tissue itself, liver cells, and interstitial connective tissue form the stroma. In other cases, however, the cancer stroma is a new formation, as is shown most plainly in many cancers of the ductus thoracicus in which the lumen of the dilated duct contains not only cancer cells but also stroma, which consists, of course, of completely new formed tissue, but of tissue which has originated from the nearest local tissue, namely, the vessel-wall.

Professor Williams, of Buffalo, has in my institute at Göttingen studied such a case in which elastic fibers were present in the stroma, the connection of which with the elastic tissue of the duct wall could be demonstrated.

This shows that the stroma is throughout an accessory unimportant, unessential component of cancer; although in certain cases the stroma is of importance in determining the character of the cancer; but that a scirrhus is not different in its nature from a soft medullary cancer is shown most clearly by the fact that the edges and the metastases of scirrhus may be entirely of a soft, medullary character.

If, as we have said, the essential character of cancer is the uninterrupted origin from preformed epithelium, from the scientific standpoint all cancers must bear, according to the customary nomenclature, the name of epithelioma. To distinguish it from other epithelial tumors it may be designated malignant, destructive, or heterotopic epithelioma; for the distinguishing characteristic is, that in cancer, epithelial cells occur in places where epithelium does not belong. Where there is a sharp line between the epithelial and non-epithelial parts of an organ, as in the gastro-intestinal tract (muscularis mucosae), the heterotopia of the cancer cells is easily shown. In other places it is the occurrence of connective tissue inclusions, especially of elastic and colloid fibers in masses of cancer cells, which proves that cancer cells are present where they do not belong; that they have forced their destructive way into other tissues.

Another result of the epithelial nature of cancer is, that the forms of cancer must be determined by the behavior of epithelial cancer cells, and it is of especial importance that however cancer cells may differ from normal epithelium (anaplasia of Hansemann) still, on the whole, the cells of the primary tumor, as well as those of the metastases, retain a definite character in their arrangement as well as in their morphologic and in their biologic behavior.

Thus, we may distinguish two groups of heterotopic epitheliomata:

(1) Those with a typical arrangement of the cancer cells;

(2) Those with an atypical arrangement.

To the first group belong (*a*) cancers (usually formed of cylinder cells) arranged after the gland type (Adenomata) which possess gland canals and complicated glandular structure, and which, especially in the gastro-intestinal tract, not infrequently produce a mucoid secretion. (*b*) Cancers which resemble epidermis in the form, character, and stratification of their cells, and which have borne for a long time the name of cancroids. It is specially important, for the doctrine that all cancer cells of metastatic growths arise from cells of the primary cancer, that in this first group of cancers, in adenoma as well as cancroids, the cells in the metastases show the same form and the same arrangement or stratification as those of the corresponding primary tumor.

The second group is composed of cancers whose cells are grouped irregularly in heaps and cords which show no typical arrangement. The cells also show less marked peculiarities, although we may say that they differ according to the individual organs from which the original tumor may have developed. I might designate these cancer forms with the word which forms the root of cancroid, namely, Cancer.

There are, however, mixed forms and transition forms between these particular types.

II

These facts give us important bases for the second principal question, that regarding the parasitic nature of cancer; for, if the primary cancer with all its metastases is nothing more, histologically and histogenetically, than a great family of epithelial cells, which all have a common origin from preformed epithelium; it is impossible that a parasitism can exist here in the same way as in the well-known parasitic diseases, such as the pyemic diseases or the infectious granulomata. Pus is a local formation, whether in a primary or a metastatic abscess, tubercles, gummata, nodules of leprosy, and actinomycosis, etc., are purely local formations wherever they grow, whether they are primary or secondary. No cellular connection exists between primary and secondary abscesses, between primary and metastatic tuberculous masses.

That pus, tubercles, etc., may arise, it is sufficient that pus cocci, tubercle bacilli, etc., arrive at a certain place. For the formation of secondary cancer it is absolutely necessary that cancer cells from the primary tumor, or from a secondary tumor originating in the same way, arrive at the spot, and continue their growth. In secondary cancers there is an effectual transplantation of cancer cells, in suppuration, tuberculosis, etc., a transplantation of parasitic organisms, which do not themselves constitute the new lesion but cause definite phenomena in the local tissue without any coöperation of tissue from the primary lesion. Thus, there exists between these two groups of processes an essential difference, and we cannot conclude that because parasites play a rôle in abscesses, tuberculosis, etc., that this must necessarily be the case in cancerous tumors. We can, however, say that if parasites play a rôle in cancer, these parasites must be of an entirely different sort from those, because they must bear the most intimate relationship to the essential cancer cells. I feel that it is not impossible that an intracellular parasite plays a part here, but it cannot possibly play an independent part; it cannot possibly be the decisive element in the tumor; it cannot determine the nature and character of the tumor, for the cells alone do this.

I consider the existence of such parasites not impossible; — but what can be done to show their presence?

Experiments to demonstrate the inoculability of tumors from one individual to another show nothing in this regard. For this is nothing but the transplantation of tissue to another individual. Periosteum transplanted to another animal is able to grow in its new host and to form cartilage and bone; or to take a more familiar example, epidermis cells planted upon the surface of a wound of another individual may assume an extreme activity. Successful inoculation of tumors is in no way different. Here it is nothing else than the production of a secondary tumor, or metastasis in a second individual. Parasites are not required.

If we had only succeeded in producing tuberculosis by means of tuberculous tissue, the truth could never have been brought that tuberculosis was produced by tubercle bacilli. The parasitic nature of tuberculosis was only permanently and definitely established by the fact that by the inoculation of absolutely clean tubercle bacilli, free from all remains of tissue, the same result could be obtained as by tuberculous tissue, only by the fact that absolutely pure bacilli always produce primary tuberculosis in proper animals. We cannot show the etiologic nature of cancer or its power of transplantation by producing new secondary cancers even in another individual but only by producing primary tumors. Until that succeeds, and by pure, artificially grown organisms, the parasitic nature of cancer has not been proven.

Another question remains to be considered, viz., whether the present condition of our knowledge demands the assumption of a parasitic origin for cancer. Long before the parasites of infectious diseases were discovered, there could be no doubt that such must exist; and even to-day there are diseases, I need mention only syphilis, in which we do not know the parasitic cause, but cannot doubt that it must be present. Is the condition similar as regards cancer?

The fact which is to be explained in cancer is the limitless, the heterotopic growth of epithelial cells. I will not enter further into the question of how this may be explained than to state that there are many possible explanations and that the facts are not such that a satisfactory explanation can only be obtained by the assumption of a parasitic influence, but that we are quite able to explain all the phenomena in the morphology and histology of cancer without parasites.

I come thus to the following conclusions in regard to the question of the parasitic origin of cancer:

(1) No one has at the present day brought proof that cancer has a parasitic origin.

(2) There is no necessity of assuming a parasitic etiology for cancer.

Dr. Carl Pfister, of New York City, presented a paper containing a summary of the treatment of three hundred cases for hernia.

ADDENDA PAGES

FOR LECTURE NOTES AND MEMORANDA OF COLLATERAL READING