the pia-arachnoid of the insane are similarly met with in the choroid plexuses of the lateral ventricles.

Discussion.

Dr. FORD ROBERTSON said he agreed so fully with Dr. Findlay that he had no criticism to offer, but he had to express the very great pleasure they had in seeing those beautiful photographs, and to follow his description of the pathological changes. He had quite demonstrated that the choroid plexus was a secreting gland. That was of the highest importance in neurology.

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*The Correlation of Sciences in Psychiatric and Neurological Research.**—By IRA VAN GIESEN, M.D., Superintendent of the Pathological Institute of the Commission in Lunacy of the State of New York.†

BEFORE this body it is unnecessary to revert to the inadequacy of conducting scientific investigations in psychiatry along the restricted plan of confining the research to material found within the asylum by some one exclusive department of investigation, such as the routine governed and mechanical methods of microscopical research. This restricted plan has largely governed psychiatric research up to the present time. Now, however, that many of the sciences tributary to psychiatry have attained a growth and capacity to be of service in psychiatric research, the restricted plan of research may be relegated to the past.

The phenomena of insanity are manifold, and the comprehension of them can only be grasped when viewed from many different standpoints—from the standpoints of many sciences. A co-operation of many sciences will bring forth a rich return

* For presentation to the Annual Meeting of Medico-Psychological Association, Edinburgh, 1898.

† In an official report of thePathological Institute of the New York State Hospitals to the State Commission in Lunacy for transmission to the legislature, the writer has endeavoured to urge the necessity of a more comprehensive view of study of the science of psychiatry. This report is composed of the following sections:

1. The beneficial results of scientific investigation of insanity.
2. The inadequacy of the present methods of investigating nervous and mental diseases.
3. The correlated branches of research in the scientific investigation of insanity.
4. The unclassified residuum.
5. General remarks on the organisation and conduction of the Pathological Institute.

From its nature this report had to be written in an untechnical form. This paper embodies in substance Sections 3 and 4 of this report.

of theoretical and practical results. A many-sided comprehensive scientific investigation of insanity is at present an imperative necessity. We are on the threshold of a new era in the study of the nervous system in both its normal and abnormal manifestations. The inauguration of this era requires the many-sided investigation of the phenomena of insanity. Different branches of science must be co-ordinated and focussed together as a search-light on the mysteries of mental diseases. They must all work hand in hand. They must be linked together and correlated, otherwise the whole aim of the work is defeated; the investigation will become one-sided and restricted, and what few facts are gained will not be open to comprehensive interpretation.

In accordance with the tenor of these introductory remarks,* the director has established several departments of scientific research at the Pathological Institute for the investigation of insanity, and each of these departments is presided over by an associate who has made a life study of the subject under his charge.

Without further preface I may invite your attention to the plan of the correlation of sciences in the investigation of nervous and mental diseases, a plan which brings psychiatric research into the great broad domains outside the province of the asylum, and which at the same time does not neglect the value of many important scientific problems within the sphere of the asylum. If, on the one hand, protests are made here and there against the exclusive plan of restricting psychiatric research to asylum material, on the other hand a corresponding endeavour has been made to indicate the more inviting fields of psychiatric research open to the comprehensive plan of the co-ordination of many branches of scientific investigation.

This glance at the value of the correlation of sciences in the investigation of mental diseases may perhaps be presented by reviewing the several departments of investigation established at the scientific centre of the New York State Lunacy System. Such a review must be made exceedingly brief, and touch only on salient features. These several departments which have been deemed necessary for a broad, comprehensive investigation of mental diseases are as follows:

I. Psychology and Psycho-pathology.

II. (A) Normal and (B) Comparative Histology of the Nervous System.

* This refers to Section 2 ("The Inadequacy of the Present Methods of Investigating Nervous and Mental Diseases") of the report from which this paper is extracted.

III. Cellular Biology.
IV. Pathological Anatomy, Bacteriology and Physiological Chemistry.
V. (A) Experimental Pathology and (B) Hæmatology.
VI. Anthropology.

It will now be in order to review these several departments in their serial order, to consider how their investigations bear on insanity, and their relation and combined value in solving some of the problems in mental and nervous maladies.

I. Department of Psychology and Psycho-pathology.

The crowning glory of psychology in these days is its emancipation from metaphysics. Psychology has become a science. It has finally shown that the phenomena of the human mind are not vague and mysterious, but that their understanding is to be gained by methods of investigation such as are pursued in elucidating the phenomena of the world of life and matter generally; by means of the same general methods of investigations which we use in gaining knowledge of a distant star or tiny organism. Modern psychology is hard at work at the laboratory table, gathering facts, using instruments of precision, conducting experiments, assimilating similar work from kindred branches of science. In brief, modern psychology is one of observation and experimentation as against speculation on the nature of the soul. It is building a foundation of facts to rest the superstructure of its doctrines and generalisations and laws of phenomena of the mind. All this has been brought about practically by the development of the science in this century. Weber and Fechner introduced scientific and inductive methods into psychology. They founded psycho-physics. Fechner invented new methods to study the laws governing the relations of the intensity of sensations to their stimuli. Helmholtz contributed much to psychology by his psycho-physiological studies on sensations. His magnificent intellect enabled him to apply the methods of a whole group of sciences, for he was mathematician, anatomist, physiologist, and a brilliant worker and technician with the microscope in unravelling the tangled fibres of the nervous system. Wundt introduced into psychology the most valuable of all methods in science, namely, the experimental method, at the Psychological Institute at Leipsic. In England John Stuart Mill, Bain, Spencer, Ward, Sully, and others, in Italy Mosso and others, have contributed their share to psychology. The names of

Professor James and Professor Münsterberg are not to be omitted in this hasty sketch of the evolution of psychology into an exact science.

If the labours of general normal psychology have grown more scientific and practical, the work of psycho-pathology, embracing the psychological study of abnormal or pathological cases, has turned out to be of special importance not only from a theoretical standpoint in revealing the inner organisation of mental life, but also from a purely practical standpoint, since it has furnished the key to the understanding and even the *treatment* of functional nervous and mental diseases. The results of psycho-pathology, some of which were obtained in our Institute, are brilliant in the extreme; they may be considered a treasure for medical science in general and for psychiatry in particular. No psychiatrist, no neurologist, can be efficient in his respective science without a knowledge of psycho-pathology. Functional neurosis, that *pons asinorum* of the neurologist and psychiatrist, and of the medical profession in general, can only be intelligently studied and successfully treated through the medium of psycho-pathology. Psycho-pathology is the *sine quâ non* of the science of insanity, because insanity is a manifestation of more or less persistent pathological phenomena of consciousness, and psycho-pathology alone possesses the methods of investigating these pathological phenomena.

The work of the French school is particularly important because of its remarkable contribution to the science of psycho-pathology. The French school, with Ribot, Binet, and Janet at its head, has been studying man's subconscious domain, a subject of the most profound importance, not only in that it touches the heart of man's social attributes, but that the understanding of the nature of the subconscious is absolutely essential for any intelligent conception of the cause and course of mental maladies.

Finally the brilliant psychological and especially the psycho-pathological studies of Dr. Sidis, *on dissociations in consciousness, linked with the parallel physiological dissociation of different realms of the brain, mark an important stage in the progress of psychology, and particularly psycho-pathology.* In Dr. Sidis' researches and studies of psycho-pathological cases, parts of the brain were dissociated from each other, and the parallel psychic manifestations could be studied by themselves. Such experimental and clinical investigations help not only to understand, but also to treat the similar isolated fields of

consciousness in different forms of nervous and mental diseases.

Psychiatry is especially indebted to psycho-pathology, because it is only through psycho-pathology that psychiatry has any hopes of becoming a science relevant to its subject matter, and of having practical methods of treatment based on a solid scientific foundation. In fact, we believe that psycho-pathology will ultimately replace the present would-be science of psychiatry. This sounds paradoxical, for psychiatry is generally considered to be the science of insanity. It claims the insane as its own. Unfortunately, psychiatry is a science in name only; it endeavours to be scientific, but fails in its attempt.

Psychiatry, in a certain sense, is an overgrowth of applying the methods of investigation of bodily diseases to those of the mind. Now it is absolutely hopeless to expect that methods applied to investigations of symptoms of somatic diseases are fit to apply to the investigation of mental maladies. These methods are absolutely incompetent, and even to a certain extent irrelevant.

The observation of the abnormal phenomena in insanity relates to two groups of manifestations—the *somatic* and the *mental.* The *somatic* or *abnormal phenomena of the body,* including the abnormal manifestations of the lower parts of the nervous system, such as paralysis and the coarser and more obtrusive abnormal symptoms of the sense organs, may be observed by the *clinical* methods of investigation. But in the study of *abnormal mental phenomena,* the disturbances of the higher forms of consciousness, and the whole domain of psycho-motor phenomena concomitant with dissociations of the higher spheres of the brain (where the nerve-cells reach their highest complexity of organisation in communities, clusters, and constellations) lie beyond the scope of clinical methods of observation, and fall within the province of *pathological psychology* or *psycho-pathology.*

It should be more universally realised that there is a sharp dividing line between the efficacy of *clinical* and *psycho-pathological* methods of investigation in the study of insanity. This is an important matter, and one about which we should have clear and definite ideas in order not to make the mistake of believing that mental phenomena may be competently observed by clinical or somatic methods of investigation.

Psychiatry, obeying the natural laws governing the general progress of science, is still clinging to clinical methods of

investigation, in attempting to explore a territory beyond their scope. No fault is to be found with psychiatry for this state of affairs. If any criticism were justifiable, it should be regarded unfortunate that the psychologist has been so backward in taking up the study of pathological psychic phenomena, or psycho-pathology, and paving the way for the psychiatrist.

In discussing advance work in the study of abnormal organic life in the hospital, let us relegate *clinical* methods of investigation to their proper province, and not attempt the impossibility of stretching them over into the domain of abnormal mental phenomena, which can only be efficiently investigated by the methods of *psycho-pathology*. This same distinction between *clinical* and *psycho-pathological methods of investigation* deserves reflection in the study of *nervous diseases*. Psychiatry ought to embrace both fields of research in the study of insanity, the mental as well as the somatic; namely, the investigation of the abnormal somatic phenomena and the pathological phenomena of the lower parts of the nervous system by clinical methods, and the investigation of the pathological mental phenomena by the methods of psycho-pathology.* It would seem appropriate, however, at present, to pin psychiatry down to the former domain where it belongs, and assign the latter to its proper sphere, pathological psychology or psycho-pathology. It is questionable if the psycho-pathologist would concede that even the pathological manifestations of the lower parts of the nervous system (and the effects of disease of these lower portions upon the higher ones), especially in functional diseases, can be properly and completely investigated by the clinical methods of neuro-pathology and psychiatry. For all parts of the nervous system are too intimately inter-related in an organic whole to expect that the normal or pathological manifestations of these lower parts of the nervous system may be thoroughly comprehended by being isolated from the rest of the system and studied by themselves; or that the phenomena of any part of the system may be fully explained without a comprehensive knowledge of the phenomena of all other parts, the highest, the lowest, as well as the intermediate parts. Viewed in perspective, the foreground of consciousness

* These methods and their application to the investigation of pathological mental manifestations are described by Dr. Sidis in a work coming from the Department of Psychology and Psycho-pathology, now in press for a coming number of the *Archives of Neurology and Psycho-pathology*.

looms up beside the activity of the highest spheres of the brain composed of the superlative *constellations* of neurons, while the vanishing point stretches away far down beside the activities of the lower and lowermost parts of the nervous system composed of mere elementary *chains* and *series* of nerve-cells. Thus psycho-pathology dealing with the pathological manifestations of consciousness *comprises a study of the phenomena of the lower parts of the nervous system* as well as the higher portions, and embraces especially the *interrelation between the two sets of phenomena in functional diseases.*

In the natural evolution of medicine, symptoms of bodily disease were worked out and differentiated first; then, after a wearisome halt behind all other departments of medicine, insanity was finally recognised as the symptom of abnormal conditions of the brain, and the methods of studying bodily symptoms were dragged over into the field of mental symptoms.

Psychiatry is an art and poses as a science. As an art it has done much. The simple recognition of the fact that insanity is a symptom of abnormal brain conditions, and the beating down of the ignorance of superstition which held the insane to be possessed of devils, accomplished an enormous amount of good, and resulted in an enlightened care of their material welfare in our present hospitals for the insane. But we ought not to mistake these advances in the art of psychiatry and think that they are scientific advances. In its wider sense, the art of psychiatry attends to the welfare of the insane as a dependent and helpless class upon the community.

The science of psychiatry deals with the whence and wherefore of mental diseases. The answer to these questions, however, psychiatry as a science has utterly failed to accomplish. A very simple and most elementary stage in the science of psychiatry was the recognition of the general fact that insanity is the symptom of pathological brain processes. This recognition rescued the insane from social revenge, at a later period from social indifference, and finally stimulated the active interference on the part of society for their welfare and humane treatment in the modern hospital of to-day. If all this progress in the art of psychiatry has been born of such an elementary and embryonic stage in its evolution as a science, how much more are we to expect in the prevention and cure of insanity in the future progress of this science?

For as a science psychiatry is yet unborn, and can be brought into the world only by the aid of psycho-pathology. We now realise clearly the fact that writings from the standpoint of psychiatry as an art must not pass for scientific disquisitions.

The psychiatrist on account of the incompetency of his methods is driven into the art field of psychiatry under the delusion that he is doing scientific work. Many in the field of psychiatry unconsciously bear out the criticism that scientific methods of investigating the symptoms of mental disease are merely an overgrowth of the methods used for investigating symptoms of bodily disease, by writing fine descriptions of the bodily ailments of the insane. Fractures and dislocations of the insane, the formation of their teeth, their palates, their hair, the occurrence of various complicating body diseases, are published in detail because the present psychiatric methods of investigation are better adapted to this sort of observations than for the investigation of insanity itself. Others find an opportunity for writing on medico-legal matters relating to the insane; still others find distraction in the elaboration of statistics; others, again, in the field of therapeutics. Therapeutics, it is true, based on empirical knowledge of drugs, has the recommendation of much common sense, because the knowledge gained thereby is founded on experience; but experience without reason is blind. The administrations of drugs, particularly in the insane, must rest on a rational basis, and this rational basis cannot come until we have an understanding and scientific explanation of insanity. When that time comes we may give fewer drugs, and probably in less quantities.

The pointing out of the unscientific character of this kind of literature may be unwelcome or unpleasant to many who are in daily touch with the insane. But if larger, broader, and more inviting fields of real scientific investigation are indicated, no fault ought to be found with this presentation of the status of psychiatry. This should be reserved for those who criticise the work of the psychiatrist unintelligently, and who offer no new pathways for the old ones. It must not be understood that this pseudo-scientific psychiatric literature, substituted for scientific work now possible by the advance of science, has no value. It has its peculiar interest; the only trouble with this psychiatric literature is that its fields of investigation are harrowed out.

The investigation of the somatic phenomena of the insane

is of the most vital importance not only theoretically but practically in their treatment, because from the body is derived the nourishment and the source of energy of the nervous system. It is therefore of the utmost consequence to understand the relation of disorders of the body to the interferences with the food supply of the nerve-cells and the exhibition of toxic agents to these cells. The general somatic symptoms in insanity should be re-written and revised as often as there are new discoveries and new theories in the progress of the pathology of bodily symptoms. Moreover, the bodily symptoms in each case in the hospital as an individual, irrespective of its class grouping or particular form of insanity, should receive detailed investigation because of the primal importance of the relation of the body to the brain.

We must be in possession of all the knowledge possible regarding the bodily ailments of the insane and of those things that pertain to psychiatry as an art, but most of them are indicating a tendency towards stereotyping in the journal literature; and, frankly speaking, gynæcological matters, sprains, dislocations and fractures, the symptomatology of mere secondary complicating diseases of the body, such as fever, &c., are really rather roundabout ways of getting at the scientific investigation of the explanation of the *mental symptoms in insanity.*

As an example of the tangle in which psychiatry finds itself at present, one may point to the hydra-headed classifications of mental diseases with fifty-four varieties of mania, and an equal number of melancholia, given in a standard compendium. There must be something wrong with a science that finds itself in such straits. Psychiatry has no methods appropriate for the investigation of abnormal mental phenomena. It must broaden out. As a science, psychiatry is absolutely dependent upon psychology and psycho-pathology and their co-relative branches of science. Psychology and psycho-pathology have developed the real methods for gaining the facts, observing the phenomena, and conducting the experiments that psychiatry needs. The great value, then, of the Department of Psychology and Psycho-pathology at our Institute is paramount in reviving the suspended animation of psychiatry.

It is equally unfortunate that both neurologists and psychiatrists have a tendency to view psychology as so much metaphysics, or to sum up the whole practical utility of psychology and psycho-pathology with the word hypnotism,

as though the sum total of the immense value of its methods of investigation and practical lessons of their teachings are bound to be centred about the phenomena of hypnosis. If there is to be any ultimate, tangible, and firm basis for the understanding of mental diseases, and a consequent rational treatment and classification of them, it is surely to come as a result of the use of the methods of psychology and psychopathology. Space forbids any more than an allusion to the great value of understanding the psychic phenomena of the normal individual by studying the disordered psychic phenomena in abnormal individuals. Scientific researches of normal, mental, and nervous processes seldom have their full value without the observation and experiment of pathological cases, themselves nature's experiments. In many forms of insanity nature is performing experiments, more ingenious and valuable for study than the psychologist, restricted to the study of the phenomena of the normal consciousness, could ever devise. Normal psychology has much to learn and profit by in exploring the domain of pathological psychology.

In one instance, at least, under the direction of Kraepelin at Heidelberg, the results of studies in pathological psychology have been most satisfactory in clearing away some of the mystery surrounding the origin of mental diseases. The extensive experiments at this school on the subject of fatigue of the nervous system have already stimulated a more exact and broader view of the study of the symptoms of insanity. But even this school has failed to study mental diseases directly at their fountain-head; it is only through such a work that we can get an insight into the nature of mental aberrations. The Department of Psychology and Psychopathology at our Institute devotes its time mostly to the study of pathological cases.

It will not be inappropriate here to make a mere allusion to three prominent cases in which the Department of Psychology and Psycho-pathology has not only cleared up much of the explanation of the symptoms, but worked out the laws of the disease, the methods of cure, and applied them successfully. Psycho-pathology yielded definite tangible results of the highest value.

The first case was from the Binghampton State Hospital, and was studied in conjunction with Dr. William A. White. The case presented limitation of the field of vision, accompanied by occasional attacks of delirium and many other phenomena of mental dissociation. The case was closely

studied experimentally; very important phenomena were elicited, and a general method for the investigation and cure of similar cases discovered.

The second case was sent to the Institute through the courtesy of Professor B. Sachs, of New York city. It was one of functional hemianæsthesia and ataxia complicated with organic disorders. Investigation controlled and eliminated the functional disorders, which were of long standing, and had previously resisted all attempts at improvement.

The third case, known under the name of "general irretraceable amnesia and double consciousness," yielded theoretical and practical discoveries of the most brilliant nature to science in general and to psychology and psycho-pathology in particular. From the investigation of this case were deduced laws guiding treatment for future cases, which, up to the time of these researches, were left to the care of providence as lying beyond the ken of human knowledge.

All of these cases were quite beyond the use of drugs, and far beyond investigation by any of the methods which neurology and psychiatry make use of, and in both cases the treatment based on theoretical studies in psycho-pathology was crowned with complete success.

The Department of Psychology and Psycho-pathology also works in the lines of *cellular psycho-pathology, correlating the different psycho-motor manifestations with the varied affections of the neuron and fluctuations in neuron energy.* This is an attempt, and the first of its kind, to bring into one comprehensive scheme and embrace in one formula *expressed in terms of the fluctuations in neuron-energy with the concomitant psycho-motor states* the infinite number of bewildering phenomena met with in nervous and mental diseases.* Along with it the laws and principles of inter-relation of the neurons are worked out; these, we hope, in due time may lead to the formation of some important laws for the scientific basis of pathology in general, and of pathology of the nervous system in particular.

This same department in connection with that of physiological chemistry is also undertaking work in comparative psycho-pathology. Diseases like catalepsy, paralysis agitans, or epilepsy, for instance, we are endeavouring to induce artificially in animals; the manifestations are closely studied and experimented upon, and are then correlated with nervous

* Vide "Neuron Energy and its Concomitant Psycho-motor Manifestations," *Archives of Neurology and Psycho-pathology*, April, 1898.

diseases in men that give like symptoms under the same conditions of experimentation.

Enough has been said to insist upon the maintenance of a Department of Psychology and Psycho-pathology at the Scientific Institute of the New York State Hospitals, as the one the most closely affiliated with, and in fact of paramount importance in, the study of insanity.

This department is provided with a reasonable outfit of instruments. It is provided with sphygmographs, cardiographs, pneumographs, chronographs, ergographs, reaction-timers, &c. Some of these instruments have been made to order; others bought in Europe have been much delayed by correspondence. In fact, the equipping of the Department of Psychology and Psycho-pathology takes an amount of time which seems unintelligible to those who might expect work to come forth from the Institute with all the haste that characterises the completion of a business enterprise in this country. The apparatus of this department is as yet rather meagre, and it serves only its most fundamental requirements. In the course of time other instruments will have to be added, as the department and its work will grow and develop. It has been thought unwise, therefore, to add apparatus to the equipment of the department beyond what is absolutely indispensable for the carrying on of the work on hand. The same is to be said of every other department in this Institute. The Department of Psychology and Psycho-pathology is under the charge of Boris Sidis, Ph. D. (Harvard).

II (A). DEPARTMENT OF NORMAL HISTOLOGY OF THE NERVOUS SYSTEM.

The first and very meagre insight into the marvels of the structure of the nervous system begins with Descartes. The keenness of perception of this remarkable man enabled him, long before the microscope had been invented, to portray the structure of the nerve-fibres, both in diagrams and in text. He considered them as minute tubules which conveyed the animal spirits from the brain to the muscles. If we substitute for the word animal spirits the modern phase nervous impulse, Descartes, in his idea of the nerve-fibres, was not so very far behind our conception of this structure at the present day.

In the early part of this century the microscope demonstrated that the nerve-fibre was not hollow, but contained a solid core, or axis. A little later investigators discovered that the brain not only contained untold numbers of these nerve

tubules, but myriads of nerve-cells. Workers in microscopical anatomy were unable to solve the riddle of the relationship of the cells to the fibres. No one knew where the fibres came from, or where they ended, nor was any one able to make out the least connection of the fibres themselves. It was, therefore, impossible to obtain any idea as to how this greatest marvel of creation did its work.

In the early thirties the minute anatomist had to study his material in fresh condition. He had no methods of preservation, nor did he enjoy the advantages of being able to cut thin, diaphanous slices from the brain to view under the microscope. To-day we have the whole armamentarium of the chemist to preserve the brain in a hundred different ways, which give as many variations of methods of study. The whole record of progress in the structure of the brain invariably goes hand in hand with a similar record of improvements in the microscope and other apparatus and in technical methods of investigation.

During the forties and fifties investigators began to shed some light on the obscurity of the structure of the nervous system by discovering that the cells and fibres were not independent of each other, but that the fibre was a prolongation of the cell, an outgrowth of its body. This at least cleared up the question as to the origin of the fibre, and physiologists derived comfort from this fact, in that they had a reasonable explanation of how, in a fundamental fashion, the nervous system operated. The nerve-cell, so to speak, was the headquarters of nervous operations, and its enormously long outstretched arm in the form of a fibre, was a device to carry the impulse to some distant part. This important fact as to the connection of nerve-fibre and nerve-cell did not contribute as much toward advancing knowledge of the nervous system as might have been expected, and until fifteen or twenty years ago the structure of the nervous system was still a puzzle. The whole nervous system was an inextricable maze of an entangled network, and its unravelling seemed impossible. There was endless controversy, born of hypotheses which had an unstable foundation of facts. But within the past ten and fifteen years the obscurity that enshrouded the nervous system has been replaced by a clear and definite insight that is almost startling.

In 1873 a distinguished Italian investigator discovered a method which has revolutionised our whole knowledge of the structure of the nervous system, and has opened boundless

fields of research in manifold directions. From the results of this method of investigation we have a final solution of the structure of the nerve-cell, the nerve-fibre, and their connections. Thus it appears to-day that the nerve-cell is like a tiny octopus. Like this animal it has a body whereby it attends to the process of digestion and assimilation. In this body a food supply from the blood-vessels is elaborated into materials which enable the cell to do its work. Like the octopus, too, from one end of the body of the nerve-cell spring out an enormous number of branching arms or tentacles; from another part of the cell body arises another arm, but different from the shorter arms or tentacles in that it is of exceedingly great length, and passes away from the body to distances hundreds and thousands of times the diameter of the cell itself. This very long outstretched arm of the nerve-cell octopus—the nerve-fibre—sometimes passes to the outer parts of the body, where it may receive messages from the eye or ear, or other sense organs; sometimes the long arm passes out to other parts of the nervous system, to transmit a particular impulse from one part of the nervous system to another. These nerve-cell octopi are ranged together in series, groups, clusters, and communities of exceeding complexity, even up to the form of constellations. A given nerve-cell octopus passes its long outstretched arm so as to touch the tentacles or shorter arms of a second octopus. The second one, in turn, passes its long arm to the tentacles of the third, and so on through an infinite set of combinations which have their highest complexity of arrangement in the highest spheres of our brain, which are the last parts to develop, both in the evolution of species as well as the individual, and which are ever unstable and prone to disintegrate by reason of this very process of retraction of the nerve-cells. In the lower parts of the nervous system retraction and the corresponding dissociation of the functioning groups of nerve-cells is less liable to occur under the influence of pathogenic agencies. For here the functions are phylogenetically older and tend to approach more or less stereotyped nature; and since stability of organisation of parts of the nervous system depends on the frequency of the impulses transmitted through the group of neurons, the lower parts of the nervous system are more firmly united than are the highest spheres of the nervous system.

The most interesting feature of this latter-day conception of the make-up of the nervous system, is that the nerve-cell,

like the octopus, possesses power of movement over its shorter arms* or tentacles. While the long arm of the nerve-cell is probably fixed, its short arms, like the tentacles of the octopus, may be thrust in or out. Consider for a moment what happens when the nerve-cell retracts its tentacles. The message can be no longer transmitted. The nerve-cell has thrown itself out of the circuit of the long arms of its fellow associates in a given group or community; they are no longer in contact with the retracted tentacle. But we should conceive that as a rule whole groups, communities, clusters, and constellations of nerve-cells functionally correlated retract *en masse* rather than individual cells. Cells cannot work as isolated individuals in the higher parts of the nervous system; they are invariably members of assemblages which have been physiologically linked together by education, use, and function. There may be partial retraction (qualitative retraction) of the individual members of one functionally linked assemblage of neurons from another assemblage, but in the phenomenon of retraction we are to picture it occurring in a mass of nerve-cells belonging to some particular assemblage, and occurring more or less simultaneously.

A message can no longer be delivered and transmitted from one part of the nervous system to another, if a mass of these nerve-cells break the circuit by retracting their arms. This is the secret of many a puzzle and mystery enveloping a very great mass of psycho-motor manifestations of the human nervous system. The object which the nerve-cell apparently has in view in retracting its arms is to avoid overwork and withdraw itself from hurtful stimuli. Retraction, apparently, of the arms of the nerve-cell is a signal of exhaustion. This retraction and expansion of the arm of the nerve-cell, in groups, systems, and communities of brain cells, drawing it in or out of the circuit of transmission of nervous impulse, is the final unveiling of the secret of a whole host of mental phenomena which hitherto have seemed mysterious to the last degree. These attributes

* Future observations, I think, are liable to show that this view is not correct. From a study of the identity of differentiation which the general structure of the neuron undergoes in the neuraxon in the form of long parallel filaments incorporated with distinct microsomes with analogous modifications of the cyto-reticulum in other somatic cells (muscle cell, ciliated cell, leucocyte, chromatophores, &c.) subservient to motility, my own observations incline me to believe that the axon is the retractile and expansive structure of the neuron rather than the dendrons or gemmules.

of extension and expansion of the nerve-cell cannot fail to attract even those with the most casual interest in the operations and development of the human mind, and hold one spellbound in the vast flood of light shed upon the explanation of insanity. Mysterious cases, for instance, of individuals who sometimes from a blow upon the head or other causes wake up and find their past lives a blank, and who virtually begin to live their lives over again as it were in a new world, such as a case recounted in Dr. Sidis' book upon the psychology of suggestion, may serve as a fair example. These cases of double consciousness, so-called, receive their only explanation in retraction and expansion of the tentacles of the nerve-cell octopus, *dissociating functioning associations of cells.*

The phenomena of hypnosis, hysteria, and of the whole great important groups of *psychopathic functional diseases* are to be explained in the same way. Some of the violent manifestations of insanity seem to be due to the retraction of the highest constellations of nerve-cells that dominate and control the lower parts of our nervous system. The lower centres being unloosed from the control of the higher ones, give rise to the phenomena found in some forms of mania (psychopathic). Discrimination as to significant and insignificant stimuli is cast aside, so the maniac is prone to respond to any passing zephyr of stimulus with a storm of excitement. His subconsciousness lacks the normal control, and is most prominently in the foreground.

The phenomenon of retraction of the neurons is also, I most firmly believe, the explanation of the cardinal symptoms of epilepsy in the manifestations of the fit. Here the retraction of the constellations and clusters in the higher parts (association centres of Flechsig) from a given stimulus is very sudden; the lower portions of the brain (sensory spheres of Flechsig, particularly tacto-motor zone) being suddenly loosed and dissociated from the inhibition and control of the higher portions, the energy of the neurons of these lower portions of the cortex is suddenly liberated with the corresponding psycho-motor phenomena.

Every one is familiar with those forms of insanity in which the patient seems oblivious to his outside environment, shown in some forms of melancholia (psychopathic). There are, again, instances where the whole foreground of consciousness has been *partially* split off by a retraction of the nerve-cells constituting the higher spheres of the brain.

These spheres are asleep. A cleft lies between them and the rest of the nervous system, caused by this phenomenon of retraction. Depending upon the qualitative degree of retraction between various assemblages of neurons in the brain some forms of psychopathic mania or melancholia might result. Thus we see that one part or another of the brain may be dissociated from the rest, and naturally the parallel manifestations of the mind are thrown out of gear.

This hasty sketch of the department devoted to the anatomy of the nervous system, perhaps, shows best of all a faint glimpse of the directions we are striving in to contribute something toward the investigation and explanation of insanity.

I should not, however, be guilty of conveying the impression that merely because the anatomist has discovered these wonderful facts about the shape of the nerve-cell and its connections, or that some evidence from my own studies tends to prove the phenomena of retraction, that the phenomena of mental operations may be postulated therefrom. The most perfect knowledge, even down to the understanding of the very molecules of the nerve-cell, would not help the anatomist or the chemist to postulate the laws and phenomena of *thought* and *consciousness,* for these are not *products* of nerve-cell activity. The brain does not secrete thought, as the kidneys secrete urine ; thought is not a material thing ; it can neither be weighed nor measured. A sensation of colour, for instance, as experienced by the eye, has no material existence in the physical world. We can only speak of the phenomena of consciousness as running parallel or being concomitant with the workings and metabolism of the nerve-cell, lest we drop into the pitfall of psychologicalmaterialism, which has been utterly abandoned long ago.

To the psychologist belongs the study of the phenomena of consciousness parallel to the physics, physiology, and anatomy of the nerve-cells in the states of these associations and dissociations. The physiological process of retraction and the changes in form which the nerve-cell undergoes, causing these dissociations in consciousness, fall within the sphere of the anatomist. The object of reverting to the department of psychology and psycho-pathology is briefly to point out the incongruity of setting forth the claims of any of these departments of our institute investigating insanities as distinct, isolated methods of research. They must all be linked together and work hand in hand. A concrete example of

this is the apportionment and yet linking together of the work in the departments of psychology and normal anatomy of the nervous system. The psychologist, for instance, studies the manifestations concomitant with the physical process of retraction of the tentacles of the nerve-cell octopus. Working conjointly, the psychologist and the anatomist show, in an ideally scientific way, the stages of the *parallelism* of the physical process in the nerve-cell and the corresponding psychic phenomena. Thus while the knowledge of nerve-cell anatomy and physiological mechanism does not postulate a knowledge of mental phenomena, the value of seeing the *parallelism* between the *material processes* and the *psychic phenomena* should be strongly insisted upon by the conjoint work in these two departments.

In the next section, devoted to the status of the science of pathology in investigating the nervous system, the same feature crops out again. In the abnormal anatomy of the nervous system as well as in the normal anatomy the necessity for correlated work with psychological and psycho-pathological investigation is still more evident.

The anatomist, however, is not by any manner of means in a position to write the last words about the structure and architecture of the human nervous system. This goal will not be attained for many years to come. He has only been able thus far to straighten out the intricate structure and connections of the comparatively elementary chains and series of nerve-cell octopi in the lower and simpler parts of the nervous system. The unravelling of the connections and associations of nerve-cells in the highest parts of the nervous system, where the cells are evolved in enormous complexity of connections in the form of constellations, hardly has been begun. By studying the developing infant, however, and patiently working at the brain of the growing child, we hope to attain in the future our best light upon this obscure domain of the anatomist.

Professor Flechsig has, however, after twenty years of work, formulated a plan of architecture of the brain which, it seems to me, is the key for a final solution of the intricacies of higher brain architecture. This plan was studied out in the brains of human embryos, children at birth and growing infants, and children where the different parts of the nervous system can be identified because they make their appearance in a progressive series from the simple, fundamental, and phylo-

genetically oldest parts to the more complex, highly organised, and most recently evolved portions.

In accordance with this plan of Flechsig, but a small portion of the brain cortex—only one third—comes in contact with the outside world through the chains and series of nerve-cells connecting the sense organs, while the great mass of the brain cortex—the remaining two-thirds—has no direct connection with the outer world, but connects and associates the scattered brain areas connected with the sense organs or muscles.

This division of the brain into these two parts—the smaller portion known as the sensory spheres and the larger the association centres—gives a wonderfully clear view into many forms of insanity if we take into account the concomitant psycho-motor phenomena produced by different degrees of dissociation of these parts, but especially by dissociations occurring in the association centres themselves by retractions of communities, clusters, and constellations of nerve-cells.

The sensory spheres are scattered about in the surface grey matter of the brain. A patch at the occipital end of the brain is the sensory sphere for vision, another corresponding to the sensory sphere for sound is situated near the apex of the temporal lobe. Similarly olfactory, gustatory, and tacto-motor sensory spheres are located in other parts of the cortex. Between the sensory spheres are interpolated the association centres. The more fundamental portions of the association centres operate to render possible a simple order of recognition of the impressions received in the sensory spheres by associating them together. In the higher regions of the association centres a still more complex order of recognition of sensory and motor impressions is possible. Finally, the constellations of nerve-cells in the frontal lobes afford a basis for the highest forms of syntheses of consciousness. *This is the association centre of association centres.*

It is in these association centres and in their connections with the sensory spheres that the phenomena of retraction of the nerve-cell play such an important part. One can well conceive the chaotic condition of ideas, or imperfect power of recognition, and a host of other abnormal mental phenomena, when retractions occurring in the groups, communities, clusters, and complex constellations of nerve-cells split off the association centres from each other or from the sensory spheres, and *produce the corresponding dissociations in consciousness.* In the lower animals the association centres grow

smaller and smaller, and finally, say, for instance, in the lower mammals, the sensory spheres lie contiguous with hardly any vestige of the association centres between them.

For the study of insanity the understanding of the structure of these higher spheres of the nervous system is of the most vital importance. It is the instability of these highest parts of the nervous system which is the essence of the whole question of insanity. Hence when we consider this aspect of the value of the department of normal histology of the nervous system, we find that its offices are absolutely imperative.

With the exception of the discovery of the neuron theory, Sidis' conception of the dissociations of consciousness, the theory of neuron energy fluctuation, the theory of the retraction and expansion of the neurons, and Flechsig's plan of the association centres and sensory spheres of the brain, are the greatest discoveries which have ever been put forth in the history of our knowledge of the nervous system. The effect of the application of these four great hypotheses (for observations* at present, in my own belief at least, are increasing their validity) will, indeed, be revolutionary in the domain of mental and nervous disease.

Observers in this department should pursue studies of the normal histology of the nervous system only after a very thorough antecedent study of the minute anatomy of all other parts of the body.

II (B). DEPARTMENT OF COMPARATIVE NEUROLOGY.

The value of the comparative study of the nervous system in both health and disease has already been hinted at in the argument for the practical value of the department of cellular biology in the scientific study of insanity. Man's nervous

* Apathy's theory of the concrescences of the neurons in the lowest parts of the nervous system is perfectly tenable. But we should remember that the stereotyped function existing through eons of time in these lowest parts of the nervous system presupposes a fixed relation of the neurons to each other. In the evolution of the higher centres, however, such as the association centres and probably the sensory spheres, the individual neurons have become independent anatomically, and the impulse is transmitted by physiological contact.

Retraction does not take place in the lowest parts of the nervous system, but must be postulated for the phenomena of the highest portions of the brain. Apathy's theory, in my judgment, should not create distrust in the neuron theory; his theory does not apply to the whole nervous system, but to its lowermost parts, such as pertain to the most automatic and vegetative functions. The homologue of the lowest parts of the human nervous system is found in the leech and other invertebrates that Apathy has studied.

system is a recapitulation of the progression of development of the nervous system in animals. This recapitulation of the nervous system, embracing its evolution throughout the whole animal kingdom, is too complex to be understood without going back to the prologue in the history of the development in the lowest animals that possess nervous organs. Apparently the first nucleus of a nervous system is found in the fresh-water hydra. This creature can expand and retract a portion of its substance by a very simple mechanism, which is the combination of both the nervous and muscular systems. It appreciates stimuli from the external environment by means of a most elementary sensory apparatus, the foreshadow of the nervous system in higher animals, and reacts by means of a primitive muscular mechanism. These two sets of mechanisms are not differentiated, as in the higher animals, into two distinct organisations, but are so alike and undifferentiated that it is difficult to distinguish the one from the other. In a somewhat higher form of development, as in an ascidian, the motor and nervous systems have become differentiated. This creature has an outer tunic, an inner digestive coat, and a muscular sac lying between the two. The nervous apparatus is exceedingly simple. It is merely a chain composed of very few nerve-cells, one end of which touches the outside tunic, and the other end the muscular coat. When stimuli from the external environment are conveyed to the tunic, the creature, by means of this nervous system, transmits the impulses to the muscular bag, and responds by muscular movements to these stimuli. The very simple nervous system in this creature is the fundamental basis for the building up of the nervous system in the higher animals. This tiny arc of nerve-cells passing between the muscle and the skin in the ascidian is the starting point which nature builds upon in evolving the wonderfully complex nervous apparatus in higher animals and in man himself. Roughly speaking, the difference between man's nervous system and that of the ascidian is not in any essential distinction in the shape and constitution of the nerve-cell, but in the fact that man possesses numerically millions and millions more, in infinitely complex adjustment, of these tiny nerve-cell arcs found in the ascidian.

Passing upward in the scale of evolution from the ascidian, as more and more of these nerve-cell arcs make their appearance, and are evolved into increasingly complex adjustment to each other, the animal gains more and more highly developed functions. In the lowest forms of animal life possessing the

nervous system, the nerve-cells are arranged in simple *chains or series*;* as the evolution of the animal grows more complex, the simple series make a greater variety of combinations with each other, so that they become gathered together into *groups*.* As the scale of evolution becomes still higher, groups of nerve-cells make increasingly complex adjustments in the form of *clusters*.* In still higher forms of animal life, the adjustment of clusters of nerve-cells become complicated into *communities*.* In man we find all the evolutionary series compounded into one complex whole. The elementary form of the nervous system in the lower animal represented in a simple *chain* or *series* of nerve-cells, is present in the lower and more fundamental parts of his nervous system, such as the sympathetic. The more complex forms are built up into *groups, clusters, communities,* and ultimately in the highest parts of man's brain the *communities* are gathered together in such a variety of combinations as to form an infinite number of highly complex *constellations*.*

In building up this plan of the nervous system from the lowest to the highest creatures, nature makes no sudden strides or leaps. It is a steady progression of piling up the simple series of nerve-cells, such as found in the ascidian, in increasing numbers and complexity of combination until we reach the form of constellations in the highest portion of man's brain. His intellectual attainments, his highest form of consciousness, his self-control, and dominance of the lower parts of his nervous system, run parallel with the activities of these constellations.

Comparative anatomy of the nervous system is invaluable as a method of going back through past ages and of witnessing how man's nervous system has been built up from the simple to the complex. All the chapters in the history of brain evolution are to come from the researches of comparative neurology. We must not expect to comprehend the architecture and phenomena of man's nervous system by considering it as something apart from the nervous system of the creatures whence he is derived. Nature did not make man's nervous system by a special fiat, nor in evolving it did she consider him to be any more or less than the final member of a continuous series in the progression of the evolution of life forms.

Man is to be looked upon as a creature of the past. For nature, in the evolution of the nervous system, has built man

* See Sidis, *Psychology of Suggestion*, chap. xxi.

on the same fundamental plan with that of an ascidian. Man's nervous system is a magnificent organisation, but in plan of structure it is the same in the ape, the dog, or even the earthworm.

Comparative anatomy of the nervous system has often given us the most striking answers to complicated questions in man's brain. For instance, when certain animals leave their aquatic habitat and spend the rest of their existence leading a terrestrial life, special sense organs become useless and disappear during the terrestrial life. The following out of the changes of the brain incident to the loss of these sense organs has thrown most important light upon some of the complicated questions of the nerves in man's brain. The enfeebled development of eyesight in the mole, and the deficient development of his portions of the brain concerned with its visual impressions, have helped us in understanding the central mechanism of vision in man's brain. The enormous development of the sense of smell and of the parts of the brain devoted to the reception of olfactory impressions in the lower animals has been of much service in contributing to the knowledge of the structure of the parts of man's brain connected with his delicate but uncomprehensive sense of smell. In fact, in the study of man's brain we are constantly driven back into the past, when it was in a simpler form, in order to understand its mechanism and operations.

Comparative neurology is of value, not only in helping us to understand the architecture of the nervous system, *but it is also destined to be of great importance in imparting knowledge of the organisation of the nerve-cell as an individual, through the study of comparative cytology of the nerve-cell.* An individual nerve-cell, a single one of the myriads and myriads composing man's brain, is a microcosm taken by itself. We are far from knowing, aside from the problem of how nerve-cells are connected with each other in the brain, how they work as individuals, how they live and die and pass through their whole life history. If we had the most perfect knowledge of all the combinations, adjustments, and associations of the countless hosts of nerve-cells in the brain, in short a perfect knowledge of the architecture, it would be of comparatively little value in the study of insanity, unless we understood the *nerve-cell as an individual.* No one could build a bridge, even with the most perfect and detailed working plans, without knowing the constitution of the building materials. So it is with the nervous system. We

may know much as to its architecture, and in fact are actually daily gaining more and more of this kind of knowledge by a great variety of methods, but we know comparatively little of the working units of the nervous system, the nerve-cells.

The internal constitution of the nerve-cells is the most pressing question of the day in the study of insanity. The all-important question is how the nerve-cell works as an individual, how it conducts nervous impulses, how it assimilates food, its mechanism of elaboration of energy from the crude food-supply which the nerve-cell obtains from the blood-vessels. If there be one all-important question in the production of insanity, it relates to the *balance between food-supply of the nerve-cells* and the *work performed or withdrawal of nervous energy*. This is a practical question, because every one knows that if more energy is drawn off from the nerve-cell than can be produced from its food-supply, the result is bankruptcy of the nervous system. Any one may see this in his daily walk of life in the man who overworks and over-fatigues his nervous system. We see this bankruptcy of the nervous system everywhere about us in the endeavour to cheat time in the pressure of hurry and haste in the activity of large cities. People expend more energy from their nervous system than they supply through food and rest. Yet such a vitally important question as to the details of the cycles of expended energy of the nerve-cell with relation to food-supply is almost unknown. Here again we must have recourse to the aid of the comparative neurologist. We must ask him to tell us the internal structure and constitution of the nerve-cells in the lower animals, because here the problem may be studied under its simplest condition. We ask him to make experiments, and to select some favourable animal to illustrate the changes of fatigue in the nerve-cell, to tell us what happens when the nerve-cell is deprived of its food-supply, to recount to us the changes in the constitution of the nerve-cell when it is called to expend more energy than it receives in nourishment. Such questions as these are of the utmost importance. As a concrete illustration I might mention an off-hand example in some work which we had undertaken some three years ago in the electric torpedo to determine what happened in the nerve-cell when over-fatigued. Two torpedoes were placed side by side. One was irritated at regular intervals with a sharp instrument, until his electric shocks became less and less and finally disappeared. Thus the nerve-cells in the brain governing the electric organ were

completely tired out and could no longer work. Without giving these nerve-cells time to recuperate, or to gain new energy by assimilating food from the blood-vessels, the animal was killed and the cells compared under the microscope with those of the second torpedo, which remained completely at rest. Thus we had side by side under the microscope, the overworked fatigued cells, and those in a perfectly normal resting condition, which had a full supply of energy. The problem was to determine not so much any outward changes in the form and shape of the cell, as its interior mechanism. Definite changes were found between the two sets of cells, changes that throw some light upon the all-important problem of how the nerve-cell does its work, and carries on its life operations.

The guidance of this department is under C. Judson Herrick, M.S. (Denison University, Ohio).

III. Department of Cellular Biology.

The science of the cell has accomplished marvels within the past few years, and from the days of Schleiden, Schwann, Purkinje, von Mohl, and Müller there have been vast strides. Inasmuch as the whole body is a vast assemblage of these tiny cells, some working together in a community, as in the kidney, the liver, and the brain, it ought to be easy to understand that the ultimate solution of the workings of the body, both in health and disease, resolves itself into a study of the changes of the individual cells. Virchow, fifty years ago, forecast that the ultimate study of disease processes, particularly in their beginning and essences, must be so devoted. The student of cellular biology looks upon the cell as a microcosm in itself, and his investigations have solved, at least to a large degree, the problem of the physical basis of heredity.

In studying the egg-cell, just after it has started on its growth to produce a new member of the species, the biologist has found that equivalent and equal amounts of a certain element of the cell are derived from both the father and mother. He has shown, furthermore, that these elements are by a most intricate process distributed in equivalent amounts to every cell in the whole body. It is on this ground that Huxley says the entire organism may be compared to a web of which the warp is derived from the female, and the woof from the male. We stand at last face to face with some

intelligent and fact-supporting basis of the mechanism of heredity, and can now have some glimpse of how immutable are the laws of heredity. This material—the germ-plasm—transmitted to the new individual, will surely pass on damages incurred by the ancestors. If a man exposes his germ-plasm to the poisonous influences of alcohol, or still worse syphilis, such damage is not confined to his individual life only, but passes on to the next generation. This damage plays a part in subtracting from the full development of the organism, especially in the most complicated tissue of the body, the nervous system. This subject of heredity is of most enormous importance in the study of insanity, but it were well that discussions of heredity in insanity might more generally rest upon the scientific basis of our present knowledge of the germ-plasm.

Cellular biology has also another province which cannot be disregarded, for we cannot expect to understand the diseases of the nervous system until we have a knowledge of the architecture and functional organisation of this system in the normal individual. The most reliable method of gaining this knowledge is to watch growth of the nervous system in the successive stages of development of the embryo, and thus realize the functional value of different parts of the nervous system. First, the lowest and most fundamental parts of the nervous system appear, those which have to do with the mere organic and vegetative functions of the body. Little by little the higher and more complex parts appear in their turn, so that we can trace, in the growth of the embryo, chapter by chapter, the whole story of evolution in a recapitulated form. The early stages of this study of the embryology of the nervous system naturally fall within the province of cellular biology, for it is in the developing egg that this science has gained its most brilliant achievements.

The province of cellular biology in regard to insanity is so intimately linked with the scope of pathological anatomy that it is difficult to dissociate the two sciences and to discuss them separately. Briefly stated, *pathological anatomy*, or the science which treats of disease processes in the body, *can make further progress only on condition of using the science of the cell.* The whole study of changes wrought by disease processes in the nervous system is absolutely dependent upon the principles and methods of cellular biology.

Perhaps the strongest argument for the value of cytology

or cellular biology in the study of the pathology of mental diseases can be realised when we perceive that Nissl's method itself is really an outgrowth and an application of the principles and exact methods of cellular biology to the nervous system. Without in the least detracting from the fame of its discoverer and the value of his great work, Nissl's method is to be considered more as an extension of the general cytological methods of cell study to the nervous system than as an innovation in a particularised technical method.

Nissl's method and its congeners should be viewed as methods of cyto-pathology which expose the morphology of the whole interior organisation of the nerve-cell in contradistinction to the crude and restrictive methods of the older pathological anatomy. These latter methods merely brought to light the external form and shape of the cells, and gave an account only of the coarser and grosser morbid changes which were so far advanced as to be destructive, inducing obtrusive changes in the *external form* and *contour* of the cells. Nissl's and the cytological methods generally (for Nissl's method of staining is but one of many of these cytological methods), however, exposing the *internal organisation* of the cells, present a hitherto entirely hidden view of the whole *normal* and *pathological metabolism* of the nerve-cell; that is, as far as the process can be comprehended from a morphological standpoint unaided by the conjoint application of physiological chemistry of the cell. It is herein that the Nissl type of method is so valuable for investigation of the diseases of the nervous system, for we are able to see the *beginning* stages of disease process in the *interior* of the nerve-cell.

The whole life history of all forms of mental and nervous disease, except the last chapters, courses hand in hand with morbid changes in the internal organisation of the nerve-cell. When the morbid process has gone on so far as to induce defects in the external configuration of the nerve-cell, it marks the closing scenes of its life. The nerve-cell then passes over into the grave, for these changes are beyond reparation; its life history is closed, its cycles of metabolism have ceased; its delicate mechanism, subservient to the expenditure and restitution of nervous energy, is irrevocably damaged, and no further expenditure of energy is possible except that issuing from the organic dissolution of the cell manifested in non-nervous energy or energy liberated in

the form of heat, or chemical reactions of organic destruction.

Future advances on the whole province of the pathological anatomy of mental as well as nervous diseases, depends upon the application of the principles and methods of cellular biology.

One exceedingly important topic also falls within the province of cellular biology, when linked with the investigation of medical sciences, and this is the study of disease processes artificially induced in the lower animals. The lower animals, even down among the invertebrates, offer us opportunities for elucidating wider and more fundamental truths concerning the cell microcosm than the higher animals, especially man.

Experiments in these lower animals, made up of relatively small colonies of cells in a simpler and more elementary form, constitute one of the most fruitful fields of inquiry as to the behaviour of the cell in the environment of disease processes. In man, and even in the higher animals, when disease processes are experimentally induced the conditions are much more complex, so much so as to frequently hide the fundamental changes of the reaction of the cell as an individual. Since man is simply an aggregation of cells, the same laws that govern the individual cell must also govern his organisation.

The experimental induction of disease processes in the more elementary organism, with a view to study the reaction of the cell in abnormal environment of pathogenic stimuli, under the simplest conditions, seems again, at first glance, to be straying from our proper pathway, the study of insanity. This, however, is not so. The nervous system is made up of myriads and myriads of the same kind of cells, marvellously organised into one organic whole. No other cell in the whole body can compare with the nerve-cell for complexity of shape and internal organisation. It is not sensible to attack the problem of cell-dissolution by selecting for study the most complicated cell in the whole body. It is plain that the proper way is to study first the course of disease processes in the simpler cells. Having learned this, we can forecast what ought to happen in the complicated differentiation of the ordinary type of somatic cell into a nerve-cell, and be prepared to understand what the changes in the nerve cell mean when it comes in contact with abnormal stimuli inducing disease processes.

We may be sure of one thing, that the nerve-cell was at one time much like any of the simpler cells of the body, and

that all these complex structures in the nerve-cells are not new creations or fiats in its evolution from the simple cell, but are merely devices and modifications of the structures present in its simply organised ancestor. In other words, a cell of simple structure like the general type of somatic cell, in undergoing the phylogenetic evolution into the nerve-cell, has not created new and specific elements in order to accomplish the duties of a nerve-cell, but has used its old and elementary structure, and by differentiations and modifications made them fit to accomplish the offices of the nerve-cell. In studying the cyto-pathology of the nerve-cell, one should hold in mind that, notwithstanding the marvellous adaptations of the cyto-reticulum and cyto-lymph of the nerve-cell wrought by evolution out of these fundamental cytologic structures common to all cells, the nerve-cell should not be considered apart from the other cells of the body. The neuron is not a specific cellular creation, its structures are homologous with other cells of humbler organisation in the body, and obey the same general basic laws governing normal and pathological metabolism. The laws which govern pathological processes (and some day these, it is to be hoped, may be expressed in terms of cell energy) operate uniformly for all of the cells of the body. Disease is a single process, but this process manifests itself in a great variety of phases corresponding with a protean expression of symptoms often grouping themselves in a distinct type as a distinct malady. One is, therefore, liable to wrongly consider the phases of the single process as individual entities and distinct processes. Hence various kinds of inflammations and cellular degenerations and other pathological processes are spoken of as individualised processes, whereas these are merely phases of the same single process.

The more cellular biology is used in the study of pathological anatomy, the less tenable becomes the idea of individualising specific morbid processes with specific diseases.

We find it advisable to recommend that provisions should be made for the associate who has the responsibility of this department to visit marine biological laboratories during a part of the summer season at least. Unfortunately, we have in this country, as compared with Europe, but few of such laboratories. Few, however, as they are, they are to be considered as the home and fountain-heads of knowledge in cellular biology. In these marine laboratories are found the best opportunities for extending knowledge of the cell.

Here is to be found a great variety of lowly organised, simply constructed marine organisms to study and experiment upon in the living condition.

Those who are studying the all-important problems of cell organisation by confining their investigations to the cell under normal environment only, hardly take the broadest conceptions of this problem. *The normal cell can never be fully understood without studying the abnormal and diseased cell.* In exposing the cell to the environment of disease processes, nature is conducting an experiment a hundredfold more ingenious than the student of normal cytology could ever devise. It will do no harm to repeat that in the sciences dealing with life phenomena the pathological method is the most fruitful.

Modern specialisation among the branches of science is creating gaps and clefts which contain more important fields for investigation than the individual departments of science themselves. He who can bridge over the rifts between the border lines of several of these sciences will discover the richest domains of investigation and gather in a good harvest of scientific truths. Unfortunately, few can occupy two fields of science, and cover the gap between. A most unfortunate gap, for instance, lies between cellular biology and the pathological anatomy of the human body—cyto-pathology—a term but newly coined. I do not hesitate to say that the overlapping of cellular biology and pathological anatomy opens the richest of all domains for the future progress of medical science.

The Department of Cellular Biology is under the charge of Arnold Graf, Ph.D. (University of Zürich).

IV. Department of Pathology, Bacteriology, and Physiological Chemistry.

The departments of pathology, bacteriology, and physiological chemistry are so intimately linked together in the investigation of insanity that they may be dealt with collectively.

Pathology, comprising the sum total of human scientific knowledge concerning the origin, course, and results of disease, had very simple beginnings. At first noxious and evil humours were supposed to gain access to the blood, and to cause the departures from health. If we translate the term "humours" into the modern expression of toxic substances circulating in the blood, the "humours" of the

older pathologists are not so far from the truth. But whence the humours arose and how they gained access to the blood was all guesswork and speculation, and "humoral" pathology was a mere makeshift to define an unknown something which circulated in the blood and caused the phenomena of disease. In later days those who were concerned in the investigation of disease processes observed with the naked eye what they could of the changes in the body after death from any given disease, and were able to see that many of the symptoms corresponded to gross, coarse, and destructive changes in the various organs. As the microscope improved, and ideas of the cell as the elementary unit of the whole body became more definite and coherent, the pathologist studied these coarser and grosser changes in the organs under the microscope, but even here he saw results rather than beginnings of the processes. Professor Prudden quotes a line from Oliver Wendell Holmes, in which the work of the earlier pathologist is compared to an inspection of the fireworks on the morning after the show.

In those days the practising physician was also the pathologist. He combined both functions. He observed disease in the living, and sought to find out its havocs amid the body structures after death. His methods, however, were limited only to a study of the topography of the lesions of the disease, and *not to the pathological processes themselves constituting it.* In short, he saw results, but knew not whence and how they came. For the real solution of the origin of these processes lay hidden, not in the gross and terminal changes in great communities and masses of cells, but within the subtle recesses of the cells as individuals.

For many years the pathologist was bewildered by the phenomena of inflammation. He was able to describe with much precision facts and observations, but he failed to understand their significance. Meanwhile cellular biology progressed with rapid strides and disclosed the marvels of the cell microcosm. The older pathologists neglected the beginning and saw only the end.

What, perhaps, puzzled the pathologist most before he had learned to peer into the cell microcosm for the solution of his problems, was the great number of important and serious diseases of every-day occurrence which seemed to leave no traces whatsoever upon the body. This was especially the case in many diseases of the nervous system. It was exceedingly perplexing, for instance, to understand

how such a dramatic and dreaded attack of the nervous system as hydrophobia should leave no traces after death. These the pathologist set down as diseases "*sine materia*," or cast them into the makeshift category of "functional" or idiopathic diseases. To-day, however, we understand why no traces may be left in the body from such serious diseases as these. The *secret lies in changes in the very inmost recesses of the nerve-cells themselves.*

The older pathologist concerned himself but little with the cell as an individual. If its shape, form, and contour were unchanged, it passed muster as being sound and normal, without regard to a whole world of changes which might be present in its internal organisation. In scrutinising the effects of disease in the interior of the cell, he looked at the outside of the cell, and not at its vital organisation within, as one might attempt to understand the contents of a book by looking at its binding. Thus, naturally enough, the knowledge of a whole host of diseases, particularly of the nervous system, was passed over unnoticed.

At the present time the pathologist in studying the diseases of the nervous system is actually peering into the mechanism of life operations going on in the laboratory of the cell. He is endeavouring to study the changes in the body of the nerve-cell—changes going hand in hand with its assimilation of food and elaboration of energy. He is able to study the changes which happen within the cell when its food-supply is interrupted or interfered with. When the food-supply of the nerve-cell is by slight increments qualitatively or quantitatively diminished, or, on the other hand, the nerve-cell expends more energy—in states of pathological fatigue—than can be recruited from the food-supply in the blood plasma, the nerve casts off *dead material*, which is removed by the lymphatics. The excretion of these particles—*the metaplasm granules**—is most important in presenting a physical basis and a measure of the slow destructive pathological metabolism of the nerve-cell which is such a prominent factor in the genesis of very many mental and nervous diseases. When the nerve-cell begins to excrete these particles it is an indication of a lack of balance between the crude food-supply of the cell from the blood-vessels and the expenditure of energy. This *excretion of the nerve-cell* is also the indication of senile degeneration, and it is most interesting to view this

* Van Giesen, "Toxic Basis of Natural Diseases." *State Hospital Bulletin*, 1897.

indication of senility of the nerve-cell advancing prematurely in a host of mental and nervous diseases where the expenditure of energy of the nerve-cell has been of a pathological and persistent character.

The pathologist is now busily seeking the degenerations occurring in the interior of the ganglion-cell when exposed to poisons, especially to those generated in the great mass of general body diseases. In the poisoning of the nervous system from general body disease, the pathologist is able to show changes within the interior of the nerve-cell which account for the delirium in cases of typhoid fever, influenza, sunstroke, &c. We are able to study the changes in the nerve-cell wrought by fatigue, to watch the nerve-cell grow old, and the signs that indicate the approach of its decadence. It is particularly interesting to watch the *premature senility* and shortening of the life of the nerve-cell by chronic *alcoholism* and *syphilis*.

Definite laws of the manifestation of energy of the nerve-cell in both health and disease, the expenditure of energy of the diseased nerve-cell, its restitution of energy in recovery from disease, with their concomitant psycho-motor manifestations formulated at the Pathological Institute, are helping to clear away the mystery of the* modus operandi *of a whole host of mental and nervous diseases.*

The rise of bacteriology is too familiar and of too recent occurrence to need any detailed account of its relation to pathological researches in the nervous system. Bacteriology, in its great public practical services to sanitation, its application by boards of health in the prevention of infectious diseases, the almost miraculous practical outcome of bacteriological studies in the antitoxin treatment of diphtheria, its great service in protecting and forewarning the healthy against disease,—all these services of bacteriology ought to make it clear that the latter is one of the most important departments in medicine for contributing practical measures to the prevention of disease.

The department of bacteriology, it should be expressly understood, does not undertake to carry on researches in the whole domain of the biology of bacteria in general, but restricts its energies to useful ends in the study of insanity, namely, the identification of bacterial poisons which are associated with nervous or mental diseases. This department purposes, however, to keep in constant touch with the broader

* Vide *Archives of Neurology and Psycho-pathology*, April, 1898.

aspect of bacteriology in general as a science, and to keep cultures of many forms of bacteria for the purpose of determining experimentally the action of their poisons upon the nervous system of animals.

When the pathologist beheld the action of these disease-producing bacteria, he at last began to approach the proximate explanation of many morbid processes, and perceived their origin. He now sees that these disease processes are nothing more nor less than chemical reactions between the forces of the body on the one hand and poisons upon the other. The process of disease should in the future be discussed in terms of fluctuations of *cell energy*. For it was soon learned that bacteria are not harmful as a rule by their mere mechanical presence, but on account of the powerful poisons which they give rise to. It is now seen that inflammation is very often the expression of a conflict between the cells of the body and the bacteria with their associated poisons.

The conservative nature of disease processes is most beautifully shown in inflammation. Inflammation is found to be a protective mechanism in the struggle of the organism for its life existence, and is the outcome of a long series of adaptations on the part of the cell. This protecting mechanism against the proximate causes of diseases extends throughout the whole scale of animal life, even to the amœba. Were it not for this protective adaptation on the part of the body cells, the highly organised forms of animal life, as well as the human race, could not exist, for by long odds the conditions producing disease, especially in civilised life, are in the ascendant over those contributing to normal health.

We must not over-estimate the direct bearing of bacteriology on the study of insanity. Bacteria are very seldom directly responsible for mental maladies, and comparatively rarely for nervous diseases. They do not attack the brain directly, nor is it to be supposed that there are specific bacteria for individual diseases of the nervous system. The action of bacteria in damaging the nervous system is indirect. The brain is so well protected against their incursions that they generally attack some other part of the body: but the nervous system is injured by the *poisons* which bacteria give rise to. The bacterial products enter the circulation of lymph spaces, come in contact with the nerve-cells, and poison them. Not an inconsiderable share of diseases of the nervous system in general take their primary origin in bodily diseases. These general body diseases, such as typhoid fever, pneumonia,

syphilis, smallpox, influenza, scarlet fever, &c., either by their poisons or by interference with the food supply of the nerve-cell, cause it to degenerate. In short, bacteriology and pathology are closely interrelated. It is not alone sufficient for the pathologist to recount the subtle changes occurring within the nerve-cell in disease, and render an opinion to the effect that these changes are due to the action of a poison. We must know what the poison is, and where it comes from. In the solution of this question bacteriology is indispensable.

The physiological chemist goes far deeper than the bacteriologist in identifying the proximate pathogenic stimuli. The devotees of medical science, particularly of pathology, are turning in eager anticipation for the ultimate solution of the question of cell degeneration to the science of physiological chemistry. What the pathologist observes under the microscope, even in the most delicate changes of cell organisation, is really far short of a causal explanation of disease processes. Behind all these morphological changes in the cell is a series of most complex chemical adjustments.

All disease processes are caused by disturbances in the chemical activities of the normal cell. The science of the chemistry of the cell is in its infancy, and the ultimate solution of the occurrence of disease processes can only be explained by the physiological chemist. For it is by means of this science that we can have any hopes of discovering the chemical composition of the cell; the reactions of the cells to poisons; the nature of these pathogenic poisons themselves, their origin, their interference with the food supply provided by the blood to the cells for the elaboration of their energy. When all these problems are solved, the abnormal changes in cells seen under the microscope will be more fully explained.

Physiological chemistry has its specific *rôle* in investigating insanity. Few of us realise the fact that at every moment of our lives poisons are generated in the body itself, which in health are obviated and eliminated. When, however, some slight hitch occurs in the delicate equilibrium of the chemical reactions going on in the complicated laboratory of the body, wide-spread havoc may occur. A poison generated within the body may escape into the blood, and while it may do comparatively little damage in the body, to the more lowly organised and more resistent body cells, it may still work harm to the sensitive and highly organised nerve-

cells. The nervous system is the most sensitive of all parts of the body to pathogenic toxic substances in general, but it is a most exquisite index of the presence of these poisons arising within the body itself. The conviction is daily gaining ground that many forms of insanity which arise so insidiously are due to self-poisoning. The microscope may show us traces of these poisons, but their source and nature can only be discovered by the method of physiological chemistry. Beyond a certain region of morphological research into the mechanism of the nervous system, the microscope alone proves an utter failure. These poisons generated by the body are of such subtle origin that it would seem almost beyond the power of science to identify or trace them. The physiological chemist attempts to identify them by examining the secretions or the blood. If unable to identify and separate them directly from other components of the body fluids, he is still able to indicate their presence: he injects the body fluids into animals and watches the physiological effects, by which he is enabled to tell whether the body is generating poisonous matters.

In identifying the poisons associated with bacteria the researches of the physiological chemist have been attended in many instances with brilliant success. In tetanus or lockjaw, for instance, the bacteriologist at first identified the bacteria of tetanus, has studied their whole life history and habits, and has even found this germ in the wilds of Africa, where the natives smear their arrows with mud of certain swamps which become partially dry during the summer season. This earth contains the spores of the tetanus bacillus, and thus the strange fact explains why the victims struck by their arrows often die of tetanus.

The physiological chemist, however, has gone further than this. He has succeeded in isolating the poisonous principles associated with the tetanus bacillus, and is actually able to separate them in the form of a powder, so that one might carry round in his vest pocket the real agent of tetanus, were it not so sinister a substance and so extraordinary a poison, for 0·065 of a gramme is absolutely fatal to animal life. Such a poison transcends in intensity almost anything that we know of among drugs and inorganic poisons. A little of the tetanus bacillus poison goes a good way, and it is not unlikely that many other bacterial poisons are almost as powerful. The poisons formed within the body itself seem to be less fulgerant in their action, of milder intensity and

insidious character, but unfortunately they offset this mildness by their tendency to remain persistent, and this presents a great barrier to the restitution of the nerve-cell, for it is deprived of an opportunity to rest and recover its pathological expenditure of energy.

Seeing that a not inconsiderable volume of mental diseases is caused or prepared for by action of poisons upon the nervous system, especially those of general bodily disease, it is of the utmost importance to trace them and use, as far as possible, practical measures against them. I think, therefore, that pathology, bacteriology, and especially physiological chemistry, need no further words of commendation in the investigation of insanity.

With all of these wonderful avenues of investigation so recently opened in the research of nervous diseases, the pathologist, physiological chemist, and bacteriologist can go but little beyond the mere description of facts and observations. *The real meaning of the great majority of all these changes in the nervous system, especially in mental maladies, their significance and the manifestations associated with them during the life of the patient, can only be made clear through the science of psycho-pathology.*

A curious division has arisen between the practical fields of nervous diseases and mental diseases, which, having extended into the scientific investigation of both, has created a very unfortunate and artificial gap. However important it may be from a practical standpoint to separate nervous diseases, which do not interfere seriously with the intelligence, from mental diseases which require a radically different treatment, the division in the scientific investigation of the two sets of diseases has been a distinct drawback in the progress of both sciences. The progress of knowledge of mental maladies has suffered the most in being considered a field of investigation apart from that of the nervous diseases. The damage in nervous diseases involves the lower and more simply constructed parts of the nervous system, and were the understanding of these simpler conditions applied to the domain of mental diseases, more progress would have resulted. One distinct aim of the Institute in many of its departments is TO BRIDGE OVER THIS ARTIFICIAL SCIENTIFIC HIATUS BETWEEN NERVOUS AND MENTAL DISEASES.

Now we find that the nervous system (even in its highest spheres) behaves like other parts of the body in the presence of disease processes. It was suggested in the preceding

section that the nerve-cell may exercise a protective agency against hurtful stimuli by retracting its arms, which also provided a period of rest for the cell to recuperate pathological expenditures of energy. When the hurtful stimulus becomes more intense, as in the case of poisons coming in contact with the nerve-cell, notwithstanding its superlative organisation, it behaves just like its humbler associates in the liver, the kidney, and elsewhere. It may undergo changes in its internal organisation in contact with the poisons of disease; its food supply may also be interfered with. We then perceive, under the microscope, signs of degeneration of the nerve-cell, as witnessed in other parts of the body when their cells are exposed to the influence of poisons. But even under the influence of poisons the nerve-cell has a wonderful degree of vitality and a large capacity for restitution, when the disease-producing poisons are withdrawn. It is a very important view to consider that the brain behaves like other parts of the body in disease processes. In studying, therefore, the changes in diseases of the nervous system, one must always hold fast to one fundamental truth, that the brain in disease must not be regarded as something apart from the rest of the body, and must not be isolated as an organ *sui generis*, having inaccessible mechanisms and mysterious powers.

It must be borne in mind that even the highest constellations of the brain are not composed of elements distinct or different from the humblest parts of the nervous system, or even the simple nerve which pursues its pathway anywhere throughout the whole body. The fundamental structure of the constituent elements is the same in each.

The study of pathology in the nervous system, then, in our Institute must always be guided by a most comprehensive knowledge of general pathology of the whole body. It is, however, extremely difficult for any one individual to have a working knowledge of disease processes in the body in general, and at the same time know enough of the nervous system to extend into this field the broad conceptions of *general* pathological research. This is the reason why the department of pathology at the Institute is at a great disadvantage; the department has not enough men to cover the whole field of pathology in its relations to the nervous system.

This insufficiency of working force in the department of pathology has also been a very serious drawback in the acquisition of that particularly valuable kind of material for

https://doi.org/10.1192/bjp.44.187.754 Published online by Cambridge University Press

investigation which is not to be found within the asylum. The opportunity for acquiring this material, so valuable in the investigation of insanity, largely determined the seat of the Institute in the great metropolitan city of the State. This material is derived from autopsies on cases in which the nervous system is damaged by the great host of general bodily illnesses. The making of autopsies; the acquisition of autopsy material of nervous diseases; the preservation of this material with the requisite great care and detail,—all involve an enormous amount of work, and we have been unable to take full advantage of the very opportunity which led to the inauguration of the Pathological Institute in New York city, namely, the acquisition of material and facilities for the study of the first stages of insanity, the importance of which was emphasised in the introductory paragraphs of this report.

The department of bacteriology is in charge of Henry Harlow Brooks, M.D. (University of Michigan).

The department of physiological chemistry is in charge of Phœbus Levene, M.D. (Imperial University at St. Petersburg, Russia), and S. Bookman, Ph.D. (University of Berlin).

V (A). Department of Experimental Pathology.

I have endeavoured to show that in these days of great specialisation it is out of the question for any individual to have the capacity to cover the entire territory. Twenty, perhaps even ten years ago, when methods of investigation in pathological research were in a comparatively elementary stage of development, and used uniformly for the investigation of disease processes in all parts of the body, a single individual could master the whole territory, and was a general practitioner and physician to boot. He could observe symptoms during the patient's life, bridge over the chasm of death, as it were, and write the sequel of the story of the disease by observing the changes in the organs under the microscope. At the present time the problems of pathological research have grown vastly more complex. The examination of different constituents of the body forms a distinct and specialised territory of research, each having particular and intricate methods adapted for its special purpose, which cannot be used uniformly for the investigation of all parts of the body. Thus the changes in the blood alone, associated

with disease, constitute a distinct field of research with specialised methods of investigation, and within the past few years an extensive literature has grown up emphasising the importance of specialised microchemical investigation of the blood.

The study of the general changes linked with disease processes throughout the body at large, including the study of tumours, constitutes a very wide field of research, and is more or less subdivided into distinct branches of investigation. The study of morbid processes in the nervous system constitutes another field of pathological research, which is in turn subdivided into many specialised branches of investigation. And the investigator who would explore this field must first traverse the domain of general pathological anatomy, must then learn the intricate architecture and construction of the nervous system in order to apply to it his knowledge of the general nature of disease processes.

Experimental pathology in its turn constitutes a highly important and specialised domain of pathological investigation. Studies in this field of research which seek to induce disease processes experimentally require special skill in conducting operations on animals, and of watching the abnormal physiological manifestations of the animal after the experiment has been performed. It can be seen then that this territory merges over into that of physiology. If pathology be restricted to the mere observation of *changes in form* within the organs and their constituent cells during the processes of disease, its power of investigation terminates quite abruptly in very many directions. We must not only observe the changes in form and structure within the cells during disease processes, but also attempt to study the changes in the *functions* of the organs and of the cells themselves. In brief, experimental pathology takes into account the *abnormal physiology* of organs when exposed to environment simulating that of disease. This most important branch of research in pathology, respecting the abnormal physiology of the organism during disease, is best conducted from the standpoint of experimental pathology. Experimental pathology fills up the gaps in knowledge of disease processes gained by studying them in the human subject alone.

Pathology embraces not only pathological anatomy and pathological chemistry, dealing respectively with changes in the structure and chemical reactions of organs, but must also take into consideration pathological physiology. Pathological

anatomy and pathological chemistry have already been touched upon in their relations to general pathology, and it is now in order to emphasise the important bearing of pathological physiology in the study of morbid processes in general, and of the nervous system in general.

As normal physiology deals with the functions of the different tissues or organs in the normal organism, pathological physiology investigates the abnormal functions in the diseased organism. But the questions which pathological physiology has to decide are much more complicated than in those of normal physiology, because of the protean aspects of disease and the great variety of phases of the process of disease. Disease is very seldom so simple a phenomenon as the expression of the abnormal functioning of a single organ of the body. The body is a united whole, and the various organs so indissolubly interrelated that abnormality of functioning in one organ may produce a wide-spread effect on the functions of the other organs. Disease is a whole complex of abnormal functions of various organs, although primarily it may result from the departure of a single organ or tissue from its normal structure, chemistry, and functions. In disease the pathological physiologist is confronted, as a rule, with a whole complex group of abnormal functions of several organs, and he has to sort out and differentiate how far the abnormal functions of each organ contribute to the general symptomatology, and to discuss the interrelation of the abnormal functions of the several organs.

Observation at the bedside is, to a large extent, a practical application of pathological physiology, but in most instances such observation can only state the substance of the question as to the nature of disease processes, namely, the origin, cause, and course of the disease, and is seldom able to answer it. Pathological anatomy may demonstrate that a given disease is followed by certain lesions in certain parts or organs of the individual, and may further show that the same lesions are always associated with the same disease, thereby making a certain relation between the two factors quite probable. But in order to change probability into certainty other methods of investigation are essential. It is necessary to reproduce the disease experimentally and artificially in animals. If the pathological lesions found in a given disease can be initiated experimentally in an entirely healthy organism, and disturbances in the functions of the organs similar to those of the disease result, the chain of

evidence demonstrating the association of the symptoms and lesions is complete. This plan is the great aim of pathological physiology.

In this experimental method, not only in pathology but in all biological science and natural sciences generally, lies the great power and advantage of modern methods of investigation over the ancient lines of research. In some instances the experimental method in the study of disease may be applied to human beings, more particularly in methods of treatment. In fact, all of our empirical knowledge of the action of drugs has been gained through experiments in pathological physiology. In fever, for instance, the modifications induced in the abnormal functions of the body by antipyretics or a cold bath are useful applications of the experimental method in pathological physiology. The opportunities for using experiment in abnormal physiological manifestations of human beings in disease are seldom afforded. Hence we have to make use of experiments on animals and compare the results with the phenomena of morbid processes in man. It may be said that pathological processes induced in animals cannot be compared with those occurring in human beings, for the organisation of each is different. This is certainly true to some extent. There are, for instance, pathological processes of the gravest import to human beings which, as yet, we have not succeeded in reproducing in animals, such as tumours, syphilis, epilepsy, the smallpox group, &c., and many diseases of the nervous system. There are certain factors vaguely grouped together under the terms predisposition and immunity, which make an individual of the human species prone to a disease process and shields an animal from the same process, and *vice versâ*. Still the idiosyncrasies of man to many diseases from which animals seem shielded only go to show how much we still have to learn of predisposition, immunity, and the factors of heredity and vulnerability in disease. These facts in themselves, on the other hand, emphasise all the more the imperative necessity of the more extensive application of the experimental method in pathology, for the diseases which seem beyond the reach of the experimental method were formerly and are now precisely the very ones which are most obscure and unsatisfactory of explanation. The exclusive privilege which man exercises over the rest of the animal kingdom in making himself heir to many diseases speaks volumes for the theory which I have advanced above, that

the predisposition of man for these diseases is due to degeneration (toxic) of his germ-plasm, and civilisation's abrogation of the laws of survival of the fittest in man.

In many instances, fortunately, one is quite justified in considering the abnormal functions of the organ in an animal, when a given disease process is induced experimentally, as equivalent to the abnormal functions in a human being in that disease.

The cardinal functions of the corresponding organs are the same in all animals with higher organisation, and the structure of these organs resembles each other remarkably closely. If then, having produced in an animal the same lesions in an organ corresponding to the ones such as are found in the human cadaver, and that animal manifests the corresponding set of symptoms, the causal relations of the abnormal functions to the structural changes rest upon a firm basis. This is the way that the brilliant and practical results of bacteriology have been achieved. Without the use of experimental pathology, bacteriology would indeed have been a sterile science in the practical domains of medicine. It would have resulted in a piling of Pelion on Ossa of mere facts of the life history of bacteria, and their all-important pathogenic qualities would have remained comparatively unexplored. We should not strive always to experiment on animals which, by the high and complicated development of their organisation, are more or less related to human beings, but, on the contrary, greater extension of the experimental method in pathology should be made in the lower animals where the brilliant work of Metchnikoff has given the key to the explanation of the phenomena of inflammation. The less complicated the organisation of the animal, the less complicated are its functions, and the easier it is to comprehend its structure and functions in either health or disease. But this field, experimental pathology in the lower animals, belongs to or is shared with the province of cellular biology, and has already been alluded to. From these studies it will then not be difficult to progress to the understanding of the aspects of disease in more complicated organisms. For our purposes, experiments to produce disease processes on the more *highly organised animals* belong more properly to the territory of experimental physiology.

When morbid processes are induced experimentally in animals, to compare the equivalence with disease in the human subject, the services of physiological chemistry, bac-

teriology, and pathological anatomy must be called upon; the secretions and excretions must be examined; the physical methods of examination used in the clinic or laboratory of normal physiology must also be taken into account. In addition, the tissues of the animal are to be examined by the microscope after death. To a casual observer it might seem then that pathological physiology, having no methods of its own, could hardly be called an independent branch of medical science. This is as little true of pathological as of normal physiology. The aims of pathological physiology, the questions it has to study and decide upon, are necessarily of its own kind, notwithstanding the fact that it applies methods of research used in other branches of medicine. Still this branch of science has an individual method, namely, animal experimentation conducted along a certain line peculiar to pathological physiology alone.

Like every other branch of medicine, experimental pathology or pathological physiology is closely, even organically, related to the other branches. It is a *connecting link* between *pathological anatomy, physiology, bacteriology,* and *physiological chemistry* on the one hand, *and clinical medicine* and *hygiene* on the other. Its work is indispensable, not only for progress in the treatment of disease, but none the less for advances in the highest art of medicine—the prevention of disease.

The study of the pathology of the nervous system is more dependent upon pathological physiology than any other system in the organism. All the other organs of the body differ from each other by the anatomical structure and by their functions simultaneously, while different parts of the central and peripheral nervous system have the same anatomical structure, and still their functions are entirely different. We can hardly see, for instance, any morphological or chemical difference between some parts of the brain, the irritation of which produces contractions of the muscles, or other parts of the brain, the irritation of which produces contractions of the circulatory system, rise of temperature of the body, and so on.

The fact that every part of the brain has only to perform a certain part of mental or nervous work in the physiological division of labour in the nervous system was shown first by Hitzig and Fritsch by the aid of animal experimentation.

They contributed a valuable part in enabling the physicians to find in a living man a tumour of the brain, and the surgeon to direct the knife to its location with almost mathematical

accuracy. Experiments of this kind corroborated the differentiation between focal and essential epilepsy, and it is to be hoped that the day is not far distant when the simulacrum of epilepsy may be artificially induced in animals through the labours of experimental pathology. If the simulacra of epileptic phenomena could be experimentally and permanently induced in animals, it would furnish the key of the explanation of this obscure process. All the facts which the pathologist and physiological chemist have gained in the study of this dire malady give no explanation at all of the *process* which gives rise to the epileptic phenomena. The key to the explanation of the process—the modus operandi—of epilepsy has only been given by the great genius of Hughlings Jackson.

Animal experimentation has also proven that extirpation of certain portions of the cortical part of the brain always produces a degeneration in the same nervous fibres, proving thereby the neuron theory and showing the location and topographical distribution of different groups of functionally related neurons. Many more examples could be added showing the value of pathological physiology for the study of the nervous system.

Morphology and chemistry alone are not now, and never will be, able to explain all the phases in the actions of the nervous system, not only because we are unable to differentiate morphologically or chemically one pathological process in the brain cell from another, but also because the same pathological process of two different parts of the brain, if their functions are different, can have a different influence upon the organism as a whole. It is, therefore, not sufficient to study the morphological and chemical changes of the nervous system in its pathological state. We must also see what influence such a diseased nervous system has upon the different systems of the organism, such as the action of the heart, the blood pressure, the respiration, the general metabolism, and so on, as these all depend upon the nervous system, and must be changed when the latter is changed. *Conversely the effects of changes in circulation, respiration, general metabolism, and changes in organic and vegetative somatic functions upon the higher parts of the nervous system must also be taken into account.* But this latter topic must be studied by the pathological physiologist and pyscho-pathologist conjointly. We can illustrate this best by the plan of studying the influence of drugs or poisons on the nervous system. Let us suppose

that we introduce into an animal certain drugs that produce convulsions or sleep; no matter whether we find morphological or chemical changes in the nervous system or not, we will not know thoroughly the nature of the action of these drugs until we examine, by all the physical and physiological methods at our command, the influence of the drugs upon the nervous system itself and all other systems of the body, the action of which is regulated by and depends upon the nervous system.

From one particular standpoint, however, this branch of research deserves special emphasis, for it relates to some questions of ultimate and practical importance regarding the insane. One of the specific *rôles* of experimental pathological investigation, in psychiatric research, lies in the determination of the action of drugs upon the nervous system. It must be confessed that in the treatment of the insane our knowledge of the effects of drugs upon the metabolism of the nerve-cells is very obscure. No one will deny that it is of the utmost importance to know what we are doing to the nerve-cells in administering drugs to the insane. At present our knowledge of the action of the drugs given to the insane is simply that of their general physiological effects; we know nothing of the chemical reaction between the constituents of the nerve-cell and the drug itself. Our knowledge of the action of drugs on the nervous system is empirical to the last degree.

Epilepsy seems to be due to the action of some stimulus which, though mild in intensity, may by its persistence act in the higher spheres of the brain. The stimulus may come from a variety of places in the body. It may arise from the intestines in the form of a mild poison, which may escape into the blood from some departure in the complicated chemical operations attending digestion; it may travel up one of the many nerves of the body from some irritation which involves the ends of these nerves; it may be due to the irritation of a splinter of bone pressing on the brain after a blow upon the head, &c. In an individual of inherent instability of brain, this constant stimulus finally causes a sudden dissociation of this part of the brain from the lower spheres beneath, by means of the retraction of the tentacles of the nerve-cells. These nerve-cells in the upper spheres of the brain become fatigued through the constant reception of the stimulus, and retract their arms to avoid the noxious impulse. But in the sudden retraction of the upper spheres of the brain, which

grasp and control the lower portions, the energy of the latter is suddenly unbridled and loosened, and the epileptic fit results. Now it is a question, if in deadening and benumbing these upper spheres of the brain by the use of bromides, so that they no longer exhibit a sense of fatigue to the stimulus, that in the course of time much harm may be done. It is quite true that the symptoms of epilepsy may be controlled in this way, but are we not poisoning the nervous system to gain this end? It were far better to ascertain the cause of the epileptic fit—the persistent stimulus coming from some distant place in the body—and attempt to remove this rather than to injure still further the highest spheres of the brain by benumbing their sense of fatigue with a poison.

If large and continuous amounts of bromides be given to animals, as has been determined in one of the New York State hospitals, the result is manifested by the phenomena of degeneration. While the drug is not given in epilepsy in such poisonous amounts as in these animals, nevertheless it must act in the same way, though to a less degree. If a perfectly sane man were continuously loaded with bromides, it would seem almost certain that in the course of time he would begin to show a dissolution of the higher spheres of the brain, whose activities are concomitant with the manifestations of the highest forms of mental operations and consciousness. It must appear, then, from this single example, how important it is to know the action upon the nerve-cell of these drugs which are given in insanity. Hence I enter a plea for experimental pathological work at our institute, and have mapped out an extensive series of experimental researches to determine the action on the nerve-cell of the drugs used in the treatment of insanity.

We have no one on the staff at present who has the requisite time or specialised training to undertake and stimulate work in the field of experimental pathology. This associate should be able, in addition to his own special investigations, to perform all the operations on animals desired by the other associates in the course of their researches, and to devise new operations and experiments as may be necessary in the course of psycho-pathological, pathological, bacteriological, or chemico-physiological investigations. In addition to this he should conduct all the physical and physiological parts of the examination, transfer and apportion the morphological, chemical, and bacteriological

material to their respective departments for detailed investigation after the experiment has terminated.

V (B). The Investigation of Blood in Insanity.

The investigation of the blood in insanity derives its importance as a distinct field of research from the fact that this is the medium of conducting the food-supply to the nerve-cell. When the nerve-cell works it expends energy, and the elaboration of energy is carried on within the body of the nerve-cells from crude food materials derived from the blood-vessels. The theory has lately become more and more substantially founded upon facts and observations, that not an inconsiderable share of mental and nervous diseases are due to the actions of poisons upon the nerve-cell. These poisons, which comprise a very large group, are sometimes bred within the interior of the body; they are often derived from bacteria, and frequently taken into the body from extrinsic sources. But there is danger of carrying this explanation of the action of poisonous substances upon the nervous system too far, and thereby under-estimating the *equally important factors of deficient food-supply and pathological fatigue of the nerve-cell in the production of nervous and mental disease.* In observing the actions of poisonous reagents upon the nerve-cells, the concomitant impairment of *their food-supply in relation to the work they perform* must also be jointly taken into account, particularly where the poisons, although mild in intensity, are of a dangerous character from their persistence and chronic action.

Investigations of the blood in the living patient, then, are of paramount importance, because in changes in the blood we have a barometer, so to speak, of the fall or adulteration of the food-supply of the nerve-cells. We have not only to consider the specific action of poisons upon the nerve-cell, but the secondary factor of the interference and adulteration of food-supply of the nerve-cell, which this poison causes by circulating in the blood.

In one of the commonest forms of insanity—general paresis—constituting 40 per cent. of the patients in the hospitals near the large cities, the cause of the disease seems to be a slow, gradual, unrelenting process of diminishing the food-supply brought by the blood, thus inducing starvation of the nerve-cells.

The investigation of the blood of insanity has proved of

such practical importance as to enable one to base on it therapeutic measures, and to indicate the percentage of cases that may be benefited by a particular line of treatment. Herein is certainly a practical application of the value of investigation of the blood of the insane. If there be one factor more important than any other in the production of mental and nervous diseases, with the exception of toxic agents, it is the *quantitative* and *qualitative impairment of the food-supply carried to the nerve-cell in the blood-vessels.** Much important work remains to be done in establishing more definitely the factor of impairment of food-supply to the nerve-cell, in relation to the genesis of mental and nervous diseases, and our Institute can ill afford to neglect this branch of research, and provide for a *systematised extension of this work in the hospitals.*

This once more may serve as a good example to show the inefficiency of the working force of the Department of Pathology in having only one associate. Pathological research work covers so many specialised fields of inquiry that a staff of at least three associates is required. I trust, however, to find that the Department of Experimental Pathology and the investigation of the blood of the insane may be carried on by a single investigator.

To sum up the requirements that are necessary to pursue pathological research in the investigation of the insane, three sub-branches should be provided for, each under the charge of a single associate; these sub-divisions are—

I. General pathological anatomy.

II. Special pathological anatomy of the nervous system.

III. Experimental pathology, including the pathological histology of the blood.

VI. Department of Anthropology.

The importance of heredity as a factor in the production of insanity has been hinted at several times in this text. The facts of the relation of heredity to insanity are to be interpreted only by applying to them the remarkable advances of cellular biology into the nature of the germ-plasm. The

* The details of chronic over-fatigue of the nerve-cell with normal food-supply, or work of the nerve-cell under conditions of deficient food-supply, involve too many technicalities to be presented in this text. Some of these details respecting the significance of the excretion of the metaplasm granules from the nerve-cell in relation to pathological expenditures of energy are presented in "The Toxic Basis of Neural Diseases," in press for a future number of the *Archives of Neurology and Psycho-pathology.*

whole essence of the problem of heredity in insanity lies in a thorough appreciation of these definite researches on the germ-plasm, and the psychiatrist who does not familiarise himself with these researches in a sister-science can hardly expect to gain any clear insight into the factor of heredity in insanity. The discussions of this subject, frequently carried on with but vague and hazy recognition of the present status of cellular biological researches into the physical basis of heredity, bear testimony to the desolate isolation of some workers in psychiatry from all other branches of science.

What are the agencies which damage the germ-plasm and cause departures from its normal constitution? Precisely the same agencies, to a certain extent, which cause degenerations or induce disease processes in other cells of the body besides the germ cell. These agencies may be summed up as poisons and other factors which depreciate the food-supply of the body cells.

While in their whole life history the germ cells are set apart from the rest of the body cells for the distinct and sole office of propagating the species, it is not possible for nature to isolate them so completely as to shield the germ cells from the damage inflicted by poisons or deficient nourishment. Thus, for example, the poison of syphilis and chronic and persistent poisoning by alcohol, both of which seem to operate largely by diminishing quantitatively or qualitatively the food-supply of the body cells, not only cause degeneration of the nerve-cells, but damage the germ cell as well. This is the reason that the progeny of parents whose nervous systems are poisoned by alcohol and syphilis is notoriously defective in the weak organisation of the superlative and most intellectually endowed spheres of the nervous system. For if a very slight defect or chemical change occur in the germ-plasm as a result of the action of these poisons, the effect in the next generation will crop out in the highest and most complexly organised parts of the body rather than in the more lowly organised and comparatively undifferentiated parts. This is why the nervous system, and, above all, its most lofty portions, are found wanting in perfection when the germ-plasm is in a pathological condition.

According to the degree of pathological changes in the germ-plasm do the effects of development of the progeny pass successively from higher to lower and lower planes of organisation in the nervous system, so that all grades of degeneracy and mental instability may be witnessed down to the weak-

minded imbeciles and idiots. The exceedingly complex molecular constitution of the germ-plasm, and the complicated process of reduction or halving of the germ-plasm in maturation of the egg and sperm cells in relation to the action of toxic agents and deficient cellular nourishment is of such urgent importance that I have made plans for the Department of Cellular Biology to approach the problem from the experimental standpoint among invertebrates which afford good opportunity of applying toxic agents to the germ-plasm.

During childhood such inherited incapacity of the energy of these higher parts of the nervous system does not always appear, unless the hereditary effects due to damage of the germ-plasm be gross and severe, for at this period such higher centres are comparatively little used. During adolescence and later life, however, when these higher centres of the nervous system are called upon for the greatest and most extensive expenditures of energy, they may fail. We then perceive the outcrop of hereditary defects. It becomes worse in the next generation, for the reason that this unstable brain energy in the first generation is liable to cause the individual to commit excesses, to set aside moral laws in decent, wholesome living, to tamper with the nourishment of the body, and introduce alcohol or other poisons into the circulation of the blood. Thus the germ cell in the second generation becomes still further degenerated. Degeneration of the germ-plasm is liable to bring about pathological conditions in the nerve-cells and other somatic cells, disturbing the general metabolism of the body; and once established, tends to set up a vicious circle increasing the degeneration in each successive progeny. The third generation becomes still more unstable in the energy of the higher portions of the brain which hold the lower ones in check. It is from this or succeeding generations that are recruited the inmates of the prison, of the lunatic asylum, of the reformatory, and of the hospital for the epileptic. We are, however, among the masses, in such a backward state of general knowledge of all these phenomena that we cannot seize these things in the beginning, where they ought to be taken in hand, but must wait for the end, so that the State has to spend millions, taking care of sickly and incurable degenerates. Spontaneous variation and environment must, of course, be taken into consideration in the march of degeneracy. But from whatever sources or combinations of these sources the degenerate and the candidate for the

prison and the asylum springs, we must identify him and have knowledge of him in the first and early stages of his pathway.

Now as to the use and purpose of anthropology. The relation of anthropology to medical science is somewhat vague. No one seems to define clearly and exactly just what anthropology is to do, or what results we may expect from it; consequently one may avoid the ponderous definitions usually given, and attempt to explain in simple language the use of anthropology in the science of medicine. Anthropology is simply a convenient term to indicate that two or three sciences are made use of collectively to study not only individual cases, but also large bodies of men. In this way the science simply makes use of anatomy, physiology, and psychology, more or less simultaneously, in investigating normal and abnormal phenomena of human life.

Now our object with anthropology is to conduct these anatomical, physiological, and psychological investigations to determine the characteristics of men with abnormal nervous systems as compared with the normal. We wish to identify the degenerate; we wish to learn departures in the physical and psychical characteristics of men at various stages along the pathway toward the prison and the asylum. At the asylum we already know fairly well what departures the insane show from the average normal man. In the asylum, however, only the last stages of mental and physical abnormalities preponderate, and we depend on anthropology to work out the initial and intermediate stages in the course of degeneracy.

In determination of the mental characteristics of degeneracy, anthropological investigation must be under the guidance of psychology and psycho-pathology. The great difficulty encountered in this investigation is the selection of a normal standard whereby to measure the abnormal departure. In America, where the population is so heterogeneous, we are immediately confronted by the difficulty of finding a standard race type to measure by, and in fact we can find no absolute standard. A perfectly normal man is a creature of the imagination. Only a standard varying between certain small limits can be used.

I ask that our constituents be reasonable in expecting immediate results from this department. The amount of work falling within the scope of anthropological investigations of the early phases of insanity is stupendous. It can

only be done little by little, and must grow and develop in the course of years.

The expectation is also cherished that the commission will see the advantage of extending this work by a larger staff, not by spending more money on the department, but by allowing us to bestow honorary associations with the Institute upon those who may prove themselves proficient in doing scientific work in this department and desire to avail themselves of its opportunities for investigation. Any work to be of value must be most carefully planned. It cannot be forced along with undue haste in accordance with what American enterprise demands in all other walks of life. Scientific work must be exempted from this pressure of haste. I must therefore ask patience in expectation of results from this department, the more so since we have no established precedent to follow in our investigation. We are doing pioneer work, and this, as a rule, meets with failures, and often has to begin over again, profiting by its mistakes, and has frequently to readjust its plan and methods of work.

A very interesting piece of work now in progress in the Department of Anthropology is a study of the correlation of the mental and physical growth of some young boys in a disciplinarian school. This has been undertaken in conjunction with Doctor Downing, of Brooklyn, N. Y. Fortunately we have an opportunity of studying these boys for several years, in order that we may fully record the relationship of psychical and physical growth, and also identify those among them who tend to deflect into degeneracy. It must be seen how important is some attempt at gaining a coherent knowledge of the insane before they make their way into the hospitals. When this is known it is bound to be of practical benefit and yield economical returns by instituting some form of control of insanity before it reaches its more hopeless stages.

In brief, one prominent purpose of anthropology at the Institute is to ascertain the proportion of cases of insanity occurring in normal individuals—in individuals who have no hereditary predisposition toward insanity—and to compare this proportion with the other cases of insanity complicated with or resulting from hereditary predisposition. For in the former class of cases insanity is more or less of an accident, and in the great majority of cases recovery is to be expected; whereas in the latter class with predisposition recovery is much less liable to occur. The determination of the question, it is plain, is most important and practical.

The instruments required for this department are comparatively simple and inexpensive. It has apparatus for testing the acuteness of the senses (all of which have to be determined in the various phases of degeneracy) and sundry instruments for physical measurements of the human body; two instruments to measure the diameter and contour of the skull, one in duplicate for the use of the State hospitals; measures for determining the cubic contents of the skull; a stereograph for tracing contours and profiles of the skull, and an anthropometer used for taking general measurements of the body.

We hope also in the course of time to make a collection of skeletons of the insane, in order to study the stigmata of degeneracy in the osseous system. The Anthropological Institute at Paris is very proud of their collection of the complete skeletons of 13 epileptics, because their histories and behaviour during life are accurately known. Seeing that the histories of our patients at the hospitals are scrupulously kept, we ought to be able in the course of time to have one of the best collections in the world for studying the osseous systems of epileptics, criminals, and lunatics. The value of this collection does not lie in the fact that it is a mere conglomeration of bones, but that it should be possible to study each skeleton in connection with the life history of its possessor.

The Department of Anthropology is in charge of Alois Hrdlicka, M.D.

SECTION 4.—THE UNCLASSIFIED RESIDUUM.

In conclusion, a paragraph from one of Professor James's essays* is most appropriate:

"The great field for new discoveries," said a scientific friend to me the other day, "is always the UNCLASSIFIED RESIDUUM. Round about the accredited and orderly facts of every science there ever floats a sort of dust cloud of exceptional observations, of occurrences minute and irregular and seldom met with, which it always proves more easy to ignore than to attend to. The ideal of every science is that of a closed and completed system of truth. The charm of most sciences to their more passive disciples consists in their appearing, in fact, to wear just this ideal form. Each one of our various *ologies* seems to offer a definite head of classification for every possible phenomenon which it professes to cover; and so far from free is most men's fancy, that, when

* "What Psychical Research has accomplished" in the *Will to Believe and other Essays in Popular Philosophy*, p. 299.

a consistent and organised scheme of this sort has once been comprehended and assimilated, a different scheme is unimaginable. No alternative, whether to whole or parts, can any longer be conceived as possible. Phenomena unclassifiable within the system are therefore paradoxical absurdities, and must be held untrue. When, moreover, as so often happens, the reports of them are vague and indirect, whether they come as mere marvels and oddities rather than things of serious moment, one neglects or denies them with the best of scientific consciences. Only the born geniuses let themselves be worried and fascinated by these outstanding exceptions and get no peace until they are brought within the fold. Your Galileos, Galvanis, Fresnels, Purkinjes, and Darwins are always getting confounded and troubled by insignificant things. Any one will renovate his science who will steadily look after the irregular phenomena. And when science is renewed, its new formulæ often have more of the voice of the exceptions in them than of what were supposed to be the rules."

From the scientific standpoint the disordered states of consciousness in insanity form a very large "unclassified residuum." In correlating these branches of sciences we have avoided the danger which Professor James indicates of restricting a branch of science to some set, fixed, and narrow limits of observation. If a branch of science be thus restricted it soon becomes walled up within itself. It travels in a rut, repeats its old observations over and over again, trying to make them appear new by merely setting them forth in new words; it finally becomes worn out and mummified. On the other hand, if a branch of science seems to be nearing the limits of its capacity to formulate new generalisations, seems to have completed its possible activities in presenting the ideal closed system of truths to which there seems nothing to add, such a science when stretched out to the outlying domain intervening between a sister science may have to begin its investigations all over again in a new and broader light. It is the value of the domains between the various medical and other *ologies* that we have endeavoured to bring out into prominence in the study of insanity. It should not be considered that our Institute has overreached itself in bringing unnecessary or irrelevant departments of science to bear upon the problems, or that in taking a stand against the restricted study of insanity it has gone to the opposite extreme in too greatly diversifying this research.

In fact a practical working force of but one Associate for the comprehensive Department of Pathological Anatomy and no representative for the Department of the Normal Histology of the Nervous System shows that this projected plan of the correlations of branches of scientific research in insanity at this Institute is still not completely developed.

We have seen some of the natural shortcomings of psychiatry, inevitable in the evolution of its progress; let us now behold the greatness of its future.

It would be a carping and disrespectful form of scientific *lese majeste* to point out these shortcomings as a stigma on the name of psychiatry, for it is truly destined to be the most majestic of all the biological and medical sciences.

These shortcomings of psychiatry only serve to show the greatness, comprehensiveness, and difficulties of the science. The other sciences in medicine and biology are elementary beside psychiatry. They are but stepping-stones to physiology, psycho-pathology, and psychiatry. For the three must be worked together in the study of the abnormal phenomena of consciousness. Psychiatry should never be so narrowly viewed as being tied down only to *insanity*, but to abnormal phenomena of consciousness in general, the domain of pyscho-pathology. The study of abnormal manifestations of consciousness presupposes a knowledge of normal psychology, while at the same time it is the only key to an understanding of normal mental phenomena.

It is not strange that psychiatry, the most difficult and comprehensive of all medical and biological sciences, has been one of the last to begin its scientific progress. Psychiatry has not lagged behind of its own accord; it has been held back and had no choice but to wait until its stepping-stones might be built. It has had to wait for the growth of psychology in general and psycho-pathology in particular; for cellular biology, pathological anatomy, neural anatomy, and their affiliated branches of research to attain sufficient development to cope with its difficult problems. When it is perceived how far these subsidiary sciences have had to develop before attaining the capacity to be of service to psychiatry, we can gain some idea of the eminence of psychiatry among the medico-biological sciences.

The spiritual trinity, psychology, psycho-pathology, and psychiatry, is destined to form the loftiest pinnacle of the temple of science. The scientific story of the rocks holds one spell-bound; the history of the egg or the mechanism of a tiny

organism has its fascination; mathematics and the laws which command the courses of the stars are awe-inspiring, but none of these sciences or their allies have the grandeur or are so deeply and essentially human as the three sciences, psychology, psycho-pathology, and psychiatry, for they unveil the greatest marvel of the universe, the human mind.

We may say with the great Scotch philosopher, "In the world there is nothing greater than man, and in man there is nothing greater than mind." A knowledge of mind, both of its normal and abnormal manifestations, is the science of sciences.

Psychiatry for the short history of its existence has done its utmost with the imperfect methods at its disposal, and is now looking for new methods to fertilise its soil, highly fruitful but difficult to till. Common neurologists and pathologists, in their mistaken nature of the true function of science, more and more lose sight of what lies beyond their microscopic field of vision. What is still sadder, they are absurdly proud of their narrowness, making a virtue of their shortcomings. They highly value the process of groping aimlessly in the dark for new details. It is only the best thinking men among them who begin to look for the light of a broad horizon. The psychiatrist, on the contrary, by the very nature of his studies, is forced more and more to broaden out the basis of his science. Nothing short of *a co-operation of all the sciences* is what psychiatry requires. The enlightened psychiatrist looks for an *organisation* of the dispersed and dismembered parts of medical science. Fortunately this enlightened spirit found a foothold in the Commission and Representatives of the New York State Hospitals, and for the first time in the history of medical science was an institute established on a broad scientific basis, an institute whose aim is to till the field of psychiatry by means of instruments and methods obtained through an organised *federation* of the most important and most vital branches of medical science. Such a federation will help the growth not only of psychiatry, but also of all the other branches of medical science. Science ought to be grateful to the psychiatrist for the mere fact that he is the first to call for a *general unified* activity of the many branches of medical science. For unification, generalisation means the discovery of *laws*, the true aim of science.

I may well acknowledge an inability to do justice to the future grandeur of psychiatry as a science, and its deep sympathy with humanity as an art. For this might better be

traced by a pen—if there be another—like the one which has wielded the most stately periods on traits of normal and abnormal human nature in the English or any other tongue —that of Henry Maudsley.

CLINICAL NOTES AND CASES.

*A Case of Chorea Gravis,** reported by J. W. Geddes, M.B., C.M., Assist. Med. Officer, and T. Aldous Clinch, M.D., Pathologist, Durham County Asylum.

The interest of the following case centres in the severity of the lesions, both macroscopic and microscopic, which were found post mortem.

The patient, aged 26, six or seven months pregnant with her first child, was admitted to the Durham County Asylum shortly after midnight, 17th May, 1898, in a state of continuous bodily movement and confined in a strait-jacket.

Family history.—An aunt is an inmate of this asylum. A father's half-sister died of phthisis. Several sisters died before the patient was born; one of these was very young, and succumbed to "brain fever."

Life history.—Previously healthy; has never suffered from chorea, fits, or insanity.

Present illness.—About two months before the illness began she moved with her vicious husband from one home to another, which, with systematic maltreatment and starvation, caused considerable depression. A month later choreic movements commenced, but she was not seen by any medical man till three days before her admission. Dr. Gordon Russell found her sane, but unable to walk owing to chorea, which increased in severity, while her mental state deteriorated *pari passu*. He recommended her removal to the workhouse infirmary, where she was certified insane and removed at once to the asylum.

On admission the choreic movements were wild and uncontrolled to an extreme degree, not limited to the limbs, but affecting the head and trunk also. Her face was flushed; she was bathed in perspiration; her limbs were considerably bruised. She paid no attention to questions, and only made inarticulate sounds.

* Read at the Annual Meeting of the Medico-Psychological Association, Edinburgh, 1898.

https://doi.org/10.1192/bjp.44.187.754 Published online by Cambridge University Press