sixty guests, including all grades, thirty-one have established themselves in their special fields of research and have been called to advanced positions. The admission of guests of this type has now become a well-established practice.

During the twenty-year period we have lost by death one member of our staff, Dr. J. M. Stotsenburg, a loyal friend of the institute, who passed to his reward on January 2, 1922.

Of the original staff of 1905 only three remain: Miss Clara N. Perine, who was secretary and clinical assistant to Dr. Harrison Allen when The Wistar Institute was incorporated, and familiar with many of the confidential conferences and influences which led to the organization of this institute. Miss Perine came to The Wistar Institute in February, 1903, and while her official duties are those of librarian, duties which she performs with efficiency, at the same time her capacity to handle financial details has brought to her an important responsibility, and during all these years her assistance in the institute's business office has been invaluable; Dr. Donaldson, whose long-time program of intensive research in a limited field has earned the generous recognition of the entire zoological world and who with his coworkers has laid the foundations for mammalian anatomical and physiological investigations for generations to come, was elected to the staff on December 18, 1905.

And as the third of this surviving triumvirate, I record my own presence as one who has watched the development of the institute from September 1, 1893.

If I might be permitted to use the anthropologists' method of stating age, I would say that The Wistar Institute has three ages, the chronological age (of 117 years), dating from 1808, when Caspar Wistar began the preparation of the first museum specimens; the intellectual age (of 32 years), dating from 1893, when the University of Pennsylvania realized what might be accomplished by creating a biological research institute, and finally the biological age (of 20 years), dating from 1905, when the institute organized its advisory board and began its productive existence.

MILTON J. GREENMAN

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RESEARCH AT THE WISTAR INSTITUTE, 1905–1925[1]

IT is my privilege to give an account of the research work at the institute during the past nineteen years, and in this connection the history of our research program should be considered. As the present occasion admits of certain intimacies, I shall, in this consideration, venture on some personal reminiscences, confident that you will not misinterpret the intent.

In 1890 I made an anatomical study of the brain of the blind deaf-mute, Laura Bridgman. Laura was a normal child up to the end of her second year. At this age she was attacked by scarlet fever, which destroyed all the organs of special sense and left her a pathetically distinguished figure for the remaining fifty-eight years of her life. To interpret the changes in her brain it was important to know the phase of its development just before her illness. For reasons easy to understand, it was not possible at that time to get young brains by which to determine this, so I turned for help to the literature. No help was forthcoming. The search of the literature revealed, moreover, but scanty information concerning the growth of the human nervous system between birth and maturity. Here was a gap—a gap covering the period of the development of the mind. It caught my attention, and the desire to help in closing this gap dominated my subsequent work.

The meager information gathered from the literature was put in a small book, "The Growth of the Brain," published in 1895. The preparation of this book helped to clarify my ideas and also it helped in formulating the problems needing solution, if a fairly complete account of the growth changes in the nervous system was to be obtained. Quantitative work on the nervous system was largely lacking at that time, and to meet this lack it was planned to use, so far as possible, the quantitative methods of weighing, measuring and counting, in addition to those usually employed. Further, as it is always necessary to work with preserved material, a systematic effort was made to determine to what degree the methods of preservation modified the weight and dimension of the nerve tissues. Such was the platform from which our problems were regarded.

Dr. Adolph Meyer in 1893 gave a course on the anatomy of the nervous system in the neurological laboratory at Chicago. For this course he used the albino rat, and thus this animal was brought to our attention. The surviving rats were left in the laboratory and further used, so that gradually those working with them grew to appreciate the fact that for many purposes, and especially for the study of growth changes in the nervous system, the albino rat was an ideal animal. Although the information sought was especially desired for man, yet it had been strongly impressed upon me that the human nervous system was hardly attainable for growth studies, and, when obtained, rarely in proper con-

[1] Read at the celebration of the twentieth anniversary of the Advisory Board of The Wistar Institute, April 13, 1925.

dition for those proposed. Furthermore, experimental work on man was out of the question. Some lower mammal was required for such investigations, while the rare cases in which suitable human material might come to hand could be utilized as controls. The rat enabled us to pursue investigations of this sort, and with its use the work in Chicago laboratory was conducted.

In the conferences at the St. Louis Exposition in 1904, Dr. Mall—pleading modesty—insisted that I replace him on the anatomical program. My paper prepared for that occasion dealt with the need for quantitative studies in anatomy. It was published in SCIENCE, caught the observant eye of Miss Perine, was passed to Dr. Greenman, and, after several intermediate steps, brought about my appointment at the institute in 1905.

The conduct of research at the institute was entrusted to me, with full freedom to develop a program. Quite naturally, the program which was adopted grew out of the earlier experiences that I have ventured to recount. Broadly phrased, this program was as follows: Studies on the postnatal growth and development of the mammalian nervous system as illustrated by the nervous system of the albino rat.

It was recognized that the relations of the work to man were of prime importance, that the nervous system was but a part of the whole animal, and that in the study of structure, technique was a servant, not a master, and thus every sort of technical method that helped was in order. In a word, then, it was our purpose to focus on the rat all the knowledge we could command in the hope of thus determining what influences were at work in the postnatal growth of its nervous system.

Without some explanation the purpose and course of our investigations are not readily understood. Misunderstandings have occurred. May I offer the "retort courteous" to a comment that is sometimes made. It is remarked, "you are interested in rats," with the suppressed clause, "not interested in other things." This is hardly a fair statement. The comment could be paralleled by remarking that an investigator who used a kymograph was interested in kymographs, and his interest stopped there. Of course, we delight in the cleverness and behavior of our chosen animal, for it is our desire to know him as intimately as possible, but from the standpoint of the research laboratory, the rat is merely an animal form with which certain problems can be studied, while, from the standpoint of science, it is the problems themselves that have a lasting importance.

A research program is indispensable for coordinate progress. It may be an excellent program or one that is mediocre, but it is always an aid and a guide. Given a program, however, the question always arises as to how it can be put in practice. Such a program assumes the presence of research men—in themselves a first-class problem. When an investigator comes to work at the institute, several questions arise: What does he wish to do? What can he do? What should he do? Finally, can he take part in the program of the laboratory? No investigator is ever asked to do anything which is not for his individual and scientific welfare. For the most part, those who come to the institute are in the early stages of their scientific work and do not bring their problems with them. It is for us, therefore, to suggest one. In the very nature of the case we are inclined to suggest some investigation that will add to our information concerning the rat, but in so doing every effort is made to select a topic which fits with the investigator's professional interest, his previous experience, and his special aptitudes. As a consequence of this adjustment to the worker, there is a spottiness in the results as published. The researches which appear are often apparently far separated in their subjects, and, at first sight, this is a bit confusing. With a large staff selected for the purpose, continuous progress in a definite direction could be made; but, under conditions as they are, the result which appears is the only one to be expected, and the reason for it lies in the fact that the development of the worker is given precedence over the orderly conduct of the work. In the end such a policy will yield more for the advancement of science than would one by which the worker was fitted to the next problem in the series by some Procrustean procedure. All the time, however, there is a prepared plan in the background, and the relation of each research to this general scheme is carefully noted. Such is the manner in which our research has been arranged.

The scope of the work needs perhaps a word of explanation. The guiding thought is progress from the general to the particular; from the large features to those which are minute. Thus, work began with a study of the growth of the entire animal; that of the nervous system followed. At this point it was evident that the growth of the nervous system should be viewed against that of all the organs, and to this end a long series of studies was made on the growth of the several organs in weight. This series of data has been assembled, and, with similar data from other laboratories, put into a memoir under the title of "The Rat." One result of these accumulated studies is that the investigator has now available a greater body of precise and coordinated information for the albino rat than for any other mammal, not excepting man.

As an aid in obtaining orderly data which will

interlock, the custom of dealing with papers used by the distinguished physiologist Carl Ludwig has been followed. The papers by the younger men have been, in every case, read critically by some member of the staff familiar with the field, and the new observations brought into relation with those previously published from the institute. Such criticism assists the younger writer in several ways and also makes it possible to tie together the results of consecutive studies in a manner that gives them cumulative value.

The formal arrangements for research at the institute include a permanent staff supplemented by investigators who come from time to time for short periods of study. One object in arranging for this second group of workers is to give men who have obtained the doctor's degree a chance to establish their own research work before assuming academic responsibilities. In the work of the staff the peculiarities of institute conditions are recognized and the endeavor made to cooperate in a certain way with university laboratories. Recognizing that long-time studies, those to be carried on for years, are more feasible under institute conditions than under university conditions, the emphasis in our staff work has been put on the sort of research for which our conditions were peculiarly suitable. It was felt that by proceeding in this manner the advance of science would be most aided, as each type of laboratory would utilize its own facilities to the best advantage.

In connection with the plan for long-time work at the institute, a word may be said about the albino rat itself, as it is an integral part of such a scheme. This is a domesticated animal always living under human care. Our first rats were brought from the Chicago colony and kept in a few cages in one of the laboratories. Later a larger colony was developed on the lower floor of the Police Station building. Finally, in 1922, through the generosity of Mr. Fels, a model colony house, planned by Dr. Greenman, was built and stocked with thoroughly clean, vigorous animals. There, under the watch and ward of Miss Duhring and her aids, a remarkably sound and prolific strain of rats is maintained for use in our own laboratories and for distribution to others. This matter is mentioned because the albino rat has been selected as our laboratory animal, and all the care and attention it receives make for constancy in its structure and functions, thus giving us an animal standardized as nearly as possible. Such an animal is to the biologist what pure chemicals are to the chemist. Experiments can be repeated through successive years with assurance of the constancy of the materials. This is no small matter, for the rat is highly responsive to its surroundings and food, and may be greatly modified by changes, especially unfavorable changes, in these conditions.

I turn now to consider the results of the past nineteen years of research. Within this period there have been published 202 scientific papers representing work done under the direction of the institute. Of this, sixteen represent studies carried out in other laboratories. In every case the investigators have received full personal credit for their work, while the institute has enjoyed the reflected glory. This is as it should be, for it is the virtue of academic laboratories that the emphasis is put on the individual rather than on the institution.

To the outer world the institute presents the picture of a cluster of investigators, yet this group has worked as a coherent and cooperative unit—and in cooperation is found the best basis for substantial progress.

It is not suitable here and now to enter into details concerning the researches which have been conducted, nor can the value of individual achievements be assessed. It is possible to indicate merely the larger phases and results, and these only in a general way. Of the 202 scientific studies which have appeared, 174 are on the anatomy and physiology of the rat, and of these, 65 deal with the nervous system. On breeding and reproduction there are 19, and some 34 are concerned with the endocrine glands. The outstanding groups of researches are those on growth, to which Dr. Hatai has contributed with such insight and appalling zeal; those on breeding and domestication, to which Dr. King has given unremitting thought and care for many years, and those on the ductless glands, a field in which the work of Dr. Hammett is distinguished by reason of his studies on the effects of removing the thyroid and parathyroid glands—effects which he has interpreted not only by the usual methods, but by others of his own devising.

It would be a pleasure to expand this review to include the smaller groups of studies, but such expansions would belong rather to a critical essay than to an address. So I pass on to some of the more general results.

As an outcome of these investigations at the institute, we know the life-history of the albino rat as a laboratory animal: its growth and some of its functional activities. From the data accumulated tables have been formed which can be used for reference, and by their aid successive studies in our own laboratory may be fairly compared and a similar comparison is possible with work done elsewhere. The rat lives thirty times as fast as man, and the growth changes in the nervous system—the most conservative of the systems—are in accord with this age

relation. As a consequence, observation on this system can be carried over to man at the equivalent ages. This removes an objection which is often made to studies on animals, namely, that the results can not be directly applied to the human case, since for the rat the contrary is true.

The best food for the rat is that used by well-nourished men. It has no dietary idiosyncrasies, thus differing from other laboratory mammals and furnishing the investigator with a test animal whose nutritional chemistry is similar to that of man.

Sugita showed that the number of cells in the cerebral cortex is a species character and made it highly probable that the difference between large and small brains in a given species is normally due to the fact that the constituent neurons vary in size rather than in number. The Kochs followed the chemical differentiation of the brain from birth to maturity—a record which still remains unique and has yet to be fully utilized. By partial inanition the growth of the brain can be diminished and the proportional weight of its divisions changed. Dr. King has shown that the rat thrives when most closely inbred even for fifty generations.

Critical periods in growth at puberty and before have been noted by Hatai and by Hammett. Finally, in the course of this work, the significance of temperament in the rat has been revealed. Rats stop growing when their familiar caretaker is absent; the isolated intestinal segment is untrustworthy as an indicator, unless the rat was at ease before being killed and was quietly anesthetized. When the thyroid apparatus is removed from rats which still show defense reactions, the mortality is 79 per cent., but when they have been made gentle and fearless through personal care before the operation, it drops to 13 per cent., as shown by Hammett's records. What appears here in the case of the rat is undoubtedly true for other laboratory animals as well, so that these observations have a general application. In this sketch of our research, I have limited myself to those results which appear to have the most general bearing at the moment, though it must be remembered that results not included here may, almost any day, reveal an equal value.

I have been speaking as though research was a pursuit which could be followed for the wishing, but such is hardly the case. Funds, facilities, and endless time-saving devices must be gathered, contrived and kept going. Some one must bear this burden, and if we have succeeded, in a measure, in carrying out our research program, it has been largely accomplished through the constant cooperation of the director of the institute—Dr. Greenman—a natural investigator temporarily engaged in administering a scientific institution. To him much is due.

The report that has just been made is a "report of progress," but the committee does not "ask to be discharged," for the future is most enticing. In response to the initial impulse, which came from the study of Laura Bridgman's brain, the foundation course of our pyramid has been in a large measure laid down. We have some notion of the gross structural composition of the rat and growth records for many of the organs. The way is open now to a more extended examination of the growth of the nervous system against this background. In one direction this means histology; in another, physiology, represented by studies of the relations of the several ductless glands to this growth process—studies like that already made on the thyroid and parathyroid—and then a study of combined deficiencies, all of these directed to the same end: a determination of the modifications in the growth of the nerve tissues which may follow. Not only is the histology of the nervous system during growth waiting for further study, but also that of the more important organs, for, with their change in weight, structural modifications must occur, and thus a series of alterations is taking place which can be followed both by histology and chemistry. So much at least is in the near foreground. We can only hope, as we do with full assurance, that the research at the institute will progress in the future under as favorable conditions as those which have surrounded it during the nineteen years just elapsed.

HENRY H. DONALDSON

THE WISTAR INSTITUTE
OF ANATOMY

SCIENTIFIC EVENTS

THE REPORT OF THE LONDON ZOOLOGICAL SOCIETY

FELLOWS of the Zoological Society, London, received, on April 14, the report of the council and auditors for the year 1924, issued in anticipation of the annual general meeting held on April 29. According to an abstract in the London *Times* it showed success in every direction. The gate-money was £69,219 for the gardens and £23,059 for the aquarium; the total number of visitors was 2,057,146, and the income from fellows' subscriptions was over £15,000, all these figures being "records" in the history of the society. The council attributes these results partly to Wembley, which brought an increased number of visitors from the provinces and from abroad, but also partly to the general improvement in the gardens and the collection and to the new aquarium. If the Zoological Gardens