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THE OPPORTUNITY OF ANATOMY[1]

It has been the custom of the past few years for the person whom you have chosen as your presiding officer to give in this hour some comprehensive survey of his own research. But last year you gave a generous allotment of your time to a symposium on the subject in which I am especially interested. At that time I presented the work of my colleagues and myself, it is true in an incomplete form, but as our experiments have since been analyzed and published, I propose, with your permission, to speak on a more general topic. I wish to return to an earlier custom of this society and consider the general subject of teaching. This year marks the end of my career as a teacher: I have taught my last class, I have ceased to be a professional teacher, but remain a professional student; but I have taught for twenty-six years, twenty-three years in a medical school, with such pleasure that I wish to record some of the changes which I have personally lived through in the teaching of anatomy.

The relation of anatomy to medical research is to be my special topic, for both in its position at the beginning of the medical course and in the nature of its subject-matter, anatomy has facilities unsurpassed for turning the minds of students toward research. From the programs of our meetings it is clear that gross anatomy is enlarging its field for research into the domain of anthropology, that neurology is at the present time one of the most brilliant subjects for research, in its almost untrodden field for the correlation of structure and function, but it is specifically of histology that I wish to speak this morning, to the thesis, that, in histology, one has a rare opportunity to teach knowledge in its growing zone. That is the definition with which Havelock Ellis in his most fascinating new book, "The Dance of Life," has illuminated the relation of science to modern education.

When I began the teaching of histology, twenty-three years ago, the subject was a minor discipline. Histology began with the discovery of the cell, and through its early period it was the isolated cell that dominated its subject-matter; but the cell, isolated by methods of maceration, dilute alcohol for the epithelial cells and weak acids for muscle, had been dead long before it was studied and so we had only general concepts concerning its form and its relation-

[1] Presidential address given before the American Association of Anatomists, 1925.

ships. The microtome was then introduced and we began to study sections. That marked the next phase of the study of histology, namely, the survey of all the organs of the body, in order to learn the general topography of the tissues. It was during this phase of the subject that text-books began to appear. When I began teaching histology we had these two techniques. We gave quite simple exercises with isolated cells of each type and about three sections each day to be stained, mounted and studied by the student. We had also frozen sections which we studied mainly for the fibers of the connective tissues. We used them, here and there, to analyze the structure of an organ; for instance, following the work of His, we shook frozen sections of lymph glands in a test tube and speculated on why the follicles fell out and the rest of the framework remained. When I took charge of our course in histology, Dr. Mall gave me only one direction, but advised me to read two books, both of them by English teachers—one, Beale's "How to Work with the Microscope,"[2] and the other a little book by Miall on "Thirty Years of Teaching."[3] The book of Beale is not a cut-and-dried text-book, with a mere statement of facts, but is the record of a man who had used a microscope with joy to find out things concerning which he was intensely curious.

Miall's book has charm. He was a teacher of biology in the Yorkshire College and his concept of teaching was to help students to love their work. To quote, "Lecturing aims at giving information, teaching aims at discipline. To both teacher and student the way in which a result is got may be far more important than the result itself. . . . When two biologists meet, they tell one another things, but they don't offer discipline to one another. The professor and an advanced class should be on something like the same terms." Or again, "The spirit of inquiry is only to be communicated by those who have it, who habitually inquire themselves."

The specific counsel which Dr. Mall gave me was that in outlining any plan of work for students one should never make the directions so specific as to rob the student of his pleasure in discovery and make him mechanically follow a definite procedure. This is the flaw in most of the formally published courses, that they tend to destroy for the student all the pleasure of personal discovery. It is clear that the nature of instructions to be given to students must vary to some extent, indeed perhaps to a marked extent, with the nature of the material to be handled. If material is rare or fragile or involves the use of anesthetized animals, then the directions must be specific, but there are certainly two subjects in the premedical sciences, namely, histology and pathology, where material can be so unlimited that the student can be given great liberty and be taught wholly in the spirit of finding things out for himself.

I have said enough to make it clear that it is of histology in its growing zone that I wish to speak. We have passed through two phases of histology, through the primary analysis of its elements and of how they are put together to form organs and we have now a third and entirely new type of subject-matter. There is, it seems to me, no longer any need of an elementary course in histology, in a medical school for which the entering students have been adequately prepared in biology and in the use of the microscope. I am well aware that many of you may not agree with this idea, but it is my real conviction. How else shall we progress in education unless we condense those things which have become so well known that they have been simplified and teach knowledge in its growing zone. By an elementary course in histology, I mean one in which the major part of the work consists in learning to describe and identify sections; this is the finished part of our subject, not its zone of growth. The subject-matter of this part is simple, is well worked out in text-books and can be readily mastered by the student without much aid. It seems to me that, in each subject taught to advanced students, the teacher should make a clear analysis in his own mind of that part of the subject-matter which is static, well known, well presented in text-books, and hence readily available to the students' own initiative, and that part which is dynamic, concerning which there are marked differences in opinion by experts, and concerning which he may confidently expect development in the coming years. There are assuredly dangers involved in regarding any body of scientific knowledge as static, but at the risk of wearying you I wish to make quite specific the type of material which seems to me feasible subject-matter for a course in histology at the present time, and I will take four examples from my own experience. In presenting these examples, I have also in mind that when a certain foreign commission visited our laboratory to study our methods of teaching, it was clearly in the minds of our guests that, without the specific material of modern biology, histology was lacking in adequate subject-matter for medical students. The frank discussion of such differences in plans for education I consider of value to teachers; it is obvious that we would give modern biology as the preparation for histology.

My first example will be the spleen. In the first place, I would give to each student a section of human spleen and of the spleen of one or two animal types

[2] Harrison, London, 1868.

[3] L. C. Miall, professor of biology in the Yorkshire College, Macmillan and Co., London, 1897.

in advance. It has been our custom to give the sections to be stained and mounted by the students at the close of the period before the subject is taken up in class; that assures ample material in the way of sections to be used for reference. For the work on the spleen the student would have, in his own collection, not only sections of the spleen but also of hemal glands and of lymph glands. Moreover, one of his sections would be a mesenteric lymph gland in which he had filled the lymphatic sinuses with ink by injecting the lymphatic vessels of the intestine. The specific work on the spleen would then be directed toward three ideas—what is the nature of the circulation in the spleen, what kind of endothelium lines its veins and what are the free cells in its pulp. Not one of these problems can be analyzed without experiment. I should begin with Mall's crucial experiment to understand the remarkable nature of the splenic circulation. To prepare the material, take a dog the day before the class exercise and tie off all the splenic veins, slip the organ back into the abdominal cavity for half an hour, at the end of which time the animal will have bled into its own spleen until the organ is twice its normal size. Then tie off the arteries and fix the entire organ in formalin without any rupture of its capsule. A second similar experiment, in which all the vessels are cut before fixation brings the organ back to the normal size, very quickly makes a convincing comparison. The class then would have frozen sections made from the two experiments; in one, both the pulp and the veins of the pulp will be engorged with blood; in the other both will be empty. This, then, would give the material from which to discuss how the splenic pulp can be so completely filled and then so quickly emptied. In a lecture one could then show why the question of whether there were specialized channels in the pulp between the arteries and the veins of the pulp dominated research on the spleen so long and how the work of Weidenreich and Mall had finally demonstrated that it is the splenic pulp as a whole that intervenes between artery and vein. In the frozen sections of such material there will be occasional places in which the blood has run out of a vein of the pulp, and such places can be used to illustrate the contrast between the pulp and its veins; but for this purpose we have in Baltimore some beautiful complete injections of the veins of the splenic pulp, made by Dr. Mall and never illustrated in his publication. In these preparations he succeeded in filling the pulp so completely with one substance and the veins with another that both are quite distinct.

Our next topic would be the nature of the endothelium lining the ampullae and the veins of the pulp; and here we would use the technique introduced by Mollier, who has shown that, when the spleen is fixed after a moderate distention produced by circulating the fixing fluid through the organ and the sections stained with an intense protoplasmic dye, such as acid fuchsin, the endothelial lining of the veins can be seen to be riddled with holes. Each student would receive such a section for his collection and could then find for himself the peculiar, widely fenestrated endothelium of the veins of the splenic pulp and could then more easily understand from such evidence how the animal can bleed into the splenic pulp and then empty the pulp so completely. We would give out one section in which a very little ink or Prussian blue had been injected in one quick spurt into the splenic artery. Such an injection of the splenic arteries represents an extravasation, if you will, into the splenic pulp, or in other words shows that the splenic pulp is in lieu of a capillary bed. These points we regard as feasible to demonstrate and that after such a presentation of the nature of the entirely unique circulation of the spleen, an organ in which there is nothing but a framework and a vascular bed, the student could take an ordinary section of the spleen, find its trabeculae and think of the meaning of its bands of muscle, identify the Malphigian corpuscles and see for himself why it is that the relation of the splenic pulp to the veins of the pulp can not be analyzed from the study of normal sections alone.

We would give one more preparation of the spleen, perhaps one of the most instructive, namely, a section of a spleen from a rabbit which had received repeated injections of trypan blue, or better of carmine, until the veins of the splenic pulp had become so clogged with cells, in our view, endothelial phagocytes or clasmotocytes, that the veins stand out in a section even when seen with the low power of a microscope. Here we would help the student to follow the endothelium of the sinuses and to see the clasmatocytes both within the sinuses and free in the pulp and then give him a chance to make his own judgment as to whether Aschoff's term of "reticulo-endothelial apparatus" is significant or confusing. We believe that reticulum and the free endothelial derivatives are both quite distinct in the pulp, but the student will surely find that the concept of a reticulo-endothelial apparatus so dominates opinion in pathology to-day that he may well spend much time in studying this section and getting his own ideas on this subject.

The second topic which I wish to present is the nature of the cells of the connective tissues as they can be analyzed by the vital technique. Here I should begin with the experiment of Professor Maximow in the analysis of the fibroblasts from the clasmatocytes of the diffuse connective tissues by the use of vital neutral red. In the work which Dr. Cunningham, Dr. Doan and I have just published on the cells of the connective tissues, we have given a technique for studying the living cells of the splenic pulp. If one takes a finely drawn out glass pipette and plunges it into the spleen of a rabbit while the circulation is active, blood and free cells will run up into the pipette and one can then make a preparation entirely comparable to a blood film. These are made either on a coverslip for fixing and staining with the ordinary technique, or on a slide which has been coated with a film of vital neutral red and Janus green combined. In such a preparation from the spleen the cells will differ according to whether the pipette entered the pulp or a follicle. If the specimen comes from a follicle, lymphocytes will predominate, but if from the pulp, then there will be two predominating types of cells, the large free clasmatocytes, filled with red blood-cells or their débris, and the monocytes with their beautifully stained rosettes and outlying mitochondria. This is not an easy technique to give a large class, because the spleen will not stand an unlimited number of such punctures, but one animal may be used for about fifteen students. These two types of cells, the clasmatocyte and monocyte, can perhaps be most easily demonstrated to a large class by making a vital film from a scraping of a freshly cut surface of the lung. For this experiment we should inject a little ink with a hypodermic needle into the trachea of a guinea pig the day before, following the work of Dr. Wislocki, and from this material we should find no difficulty in securing for every student a successful preparation. I may say in passing that the method of puncture entirely solves the question of giving a class good films of bone marrow, both for fresh material and for fixed smears. It does not matter in the least that in our own laboratory there are two opposing views concerning the interpretation of such specimens, we believing that the clasmatocytes and monocytes represent two different functional strains of cells, while Dr. and Mrs. Lewis believe that they are one strain. Indeed such differences in interpretations are as stimulating and valuable to our students as they are to ourselves. When you can bring out such points of difference of real significance to the study of what cells actually do, then the student knows that he is studying a growing zone of medicine. Such differences are only of value to a student when both points of view are presented to him with entire fairness. For our own work we regard that the separation of these two strains of the cells of the connective tissue is of value because we were also working on tuberculosis last spring and obtained evidence which convinced us that it is specifically the monocyte which becomes the epitheloid cell in tuberculosis. This concept seems to us to open up an entirely new range of experimentation in connection with tuberculosis, in which it will be possible to survey the whole subject of the relationship of clasmatocytes, monocytes and lymphocytes in this disease.

The next subject which I wish to discuss is the teaching of the pancreas. Here we would follow the work of Dr. Bensley. We would give our student sections of the pancreas, selected in different functional states, as Dr. Bensley has taught us, to show the maximum of the basophilic substance and the maximum of zymogen granules. For the class work we would give a bit of the fresh pancreas of a rabbit, and sometimes a second preparation after an injection of pilocarpin to show an emptying of the zymogen granules. We would then give the pancreas of the guinea pig with the vital injection of neutral red for the islets, have the experiment of the counting of a small bit of the organ, and hunt for the individual islet cells either in the septa or from more completely teased bits of the tissue. On the next day we would give the vital injection of the Janus green for the mitochondria, the beautiful demonstration of the controacinar cells by the injection of methylene blue and finally the mixed injection of pyronin and Janus green. Ever since Dr. Bensley published his studies on the pancreas we have tried for a satisfactory demonstration of the blind ducts to the islets, and this year we got such a clear demonstration of the point that no student could miss it. By chance we made an injection of the pyronin of double strength combined with Janus green and let the preparation stand a half hour; then every islet was clearly stained in the Janus green and the plexus of the ducts stood out beautifully distinct in the pale red of the pyronin. I think that no student could look at the demonstration of the living centroacinar cells with their processes reaching far out between the acinar cells without realizing how inadequate ordinary sections are to demonstrate them. After a student has made such a study of living pancreatic cells, sections may seem a little dull to him, but they will serve to remind him of what the pancreas really looks like and we are confident that the student would still have some vivid memories of the real organ in his mind to aid him in physiology and pathology.

The fourth illustration which I wish to give is from the reproductive system. Our material for this subject would depend on the work of Ancel and Bouin, Stockart, Evans and Long, and Corner. It happens that the laboratory in Baltimore is near a slaughter house and so an abundant supply of material from the pig is available. We would give each student or each two students an entire uterus and ovaries from a pig. Then, following the work of Corner, we would have each student study the ovary with reference to its condition in the oestrous cycle and whenever an ovary was found with a recently ruptured follicle, the tubes or the uterus would be washed out by Corner's technique and the ova recovered. Frozen sections would be made from a corpus luteum selected to show the greatest amount of fat and the sections stained with Sudan III. On the next day each student would receive a pregnant uterus and study the foetal membranes and placentation. In our course this day's work was developed by Dr. Wislocki, who gave a demonstration of comparative placentation from his own work. Each person teaching in a course should thus enrich it with the material of his own research. After such a study in the laboratory the student would not find it hard to study sections of ovaries; all sections of the ovary and of the uterus of whatever animal used should now be given out with a record of what phase in the cycle they represent. It seems to me anatomists have contributed more in the past few years to the analysis of the reproductive cycle than all clinical experience put together.

I trust that you will pardon the detail with which I have given these illustrations; they show how the material for a course in histology can be built up from research and they represent material that is entirely feasible from the standpoint of experience. It is all readily obtained and not too difficult to analyze. I have intended these examples to show the difference between an elementary and an advanced course in histology. Such plans for material I am convinced should be frequently changed in any course, if it is to have life and vigor. Sometimes a wholly new arrangement of the sequence of a course will give new plans of presentation, or a new technique will develop in research that will give a whole new range of material. Material should be frequently dropped from a course and new specimens brought in. In a word, it is of more importance that the material of a course should be thoroughly interesting to the teacher himself than that he should try to cover the entire ground of his subject each year.

I am quite aware that besides the general criticism of this concept of the type of course in histology, there will be the direct criticism of the pathologist that in such a course the student does not get such a specific knowledge of the characteristics of normal human material as to give him a nice discrimination of early pathological changes. In this connection it is my judgment that courses should not be too closely dovetailed because in the medical school the student gains by having similar subjects from different viewpoints. I think that the histologist can better afford to use sections from different animals so selected as to demonstrate function in the clearest way possible or else selected to show variations in structures of the different experimental animals, such as the marked variation of bronchial musculature, that are at the present time significant in medical research and leave to the pathologist the human material, over which he has such a vastly greater control and concerning which he is almost certainly more competent to judge.

It has come to my attention in late years that the directors of physical training in all secondary schools, even those for girls, receive a higher salary than any of the very most successful of those teachers who are concerned only with the intellectual side of education. I have finally found some comfort in this unwelcome fact in the thought that at least no teacher of physical exercise commits the cardinal sin of thinking that he can develop the muscles of his students for them by exercising his own muscles. I want to stress the idea that the value of a laboratory to the student is that it is a place where he can work. The student could get facts more quickly out of a book; a text-book that tends to take a student away from his microscope is a poor aid to a course in histology. Moreover, the teacher does not need to point out to the student the things in his section which the student can find for himself. For example, when the student is studying blood-vessels the teacher may show him a corrosion of the organ and call his attention to the number of orders of vessels in a given layer; he should show him how to dissect with the focusing screw of the microscope the coats of vessels in some such membrane as the pia mater, but he does not need to find for him the vessels in sections. Most of all the teacher does not need to concern himself with aiding the student to memorize; for that the student can be entirely responsible himself. If I were to give a young teacher advice concerning the directing of a laboratory course, it would be this; see that the material is carefully chosen and excellent in quality before it is given out, remember most of all that the period of laboratory belongs to the student for his work; when you do demonstrate to a student let it be to show him that there is much more in his material than he has been seeing, that research involves careful observations and records as well as interpretation, and when you leave him be sure that he has a fresh impetus for his own work.

There is a double problem in all medical teaching; medical schools are founded to train physicians, who shall practice medicine, and research workers, who shall advance medical science; that these two groups are not entirely distinct all medical history attests. I do not minimize the importance of training practitioners of medicine, indeed in all schools they make the larger group of the students, but it is entirely clear that unless teachers of medicine attract and train those who are to be teachers in the next generation, the profession will die at its source. But, while any given school will train only a small percentage of its students to become professional investigators, nevertheless all teaching in the sciences can and should depend on the methods of research. All the class can be taught in the spirit of research, which means that it is more important for the student to be able to find out something for himself than to memorize what someone else has said. Does any one doubt that this principle applies to diagnosis? Certainly in the practice of medicine every case is a problem; and therefore a plan of instruction for the practice of medicine that allows great range for the idea of solving problems must be the ideal one. The knowledge of what has been done must play a large rôle in the training for any profession; nevertheless, the ability to solve a problem is so much more difficult to acquire than the ability to memorize facts that education should stress the one even at the expense of the other. Indeed the facts which one remembers from one's own experience or from the experience of one's profession are merely the tools with which to work.

The ability to catch the imagination of young people and direct their interests toward research is quite a special gift in a teacher and each school must have some members of its staff who enjoy this type of teaching if that school is to contribute toward the training of research workers. In the days when I first started the study of medicine, the attitude toward the research student was entirely different from what it is now. Then, from the student's standpoint, it was unpopular to do research, and the one who undertook it had little sympathy either from his home or from his fellow-students. At present most of the outside influences to be summed up under public opinion favor research. Nevertheless, I believe that the best method of getting students interested in research is now the same as it was then, namely, through an interest in ideas presented by a teacher who has the power to catch the imagination of the gifted student. It may be that the student will apply for research, it may be that the teacher will suggest a problem to a student, but it is essential that student and teacher shall be in sympathetic understanding. The extent to which the student's mind will be turned toward research is in direct relation to the quality of intellectual leadership on the part of the teacher; this quality is brought out both in lectures and in informal discussions with students. In connection with lectures it is my fixed opinion that they should be few in number and that they should not aim at giving any comprehensive body of approved facts such as are rightly set down in text-books, but they should deal with the ideas in which the subject is growing. A static subject needs no lectures.

In all the discussions concerning a comparative analysis of the differences between European educational systems and ours, the point is brought out that in Europe the student has much greater freedom of choice and sequence of courses than we permit, and, correlated with this freedom of choice, is his vastly greater practice of wandering from one university to another. In Europe the best students wander freely. I can see great advantages in freedom of choice for the student; in essence it enables him to choose his teacher. I should like to see a student able to try medicine, then law or engineering on his own initiative, to find out what he really likes best without any feeling of failure in his mind; nevertheless, I believe that there is a point of far greater significance to education than the discussion of freedom of choice of a course and this point is freedom within the course. I happen to know that one of the most famous of the European courses in histology was conducted in the following manner: the teacher sat in the center of the room, with a slide and a microscope, and his two hundred students sat around him, each with a microscope and a section from the same block and each student followed his section under the microscope while the teacher described it. That is drilling, not leading; that it gives thoroughness of information and respect for authority, I do not doubt, that it satisfies the average student, I grant. I must say, also, that it gives an illustration, that there is no one method of teaching, for it is true that the nation in which large classes were taught in this way has produced more investigators than we have done. But the system was saved by the fact that there were other factors in the community as a whole that favored research, so that there were those whose interest survived the system, and, when they undertook research, they were then given the utmost freedom. Nevertheless, I believe that the concept of freedom for intellectual life on the part of the student within the course is a far greater type of teaching. Rules of how to teach can not be given, but the negative side can be expressed. I do not believe that a teacher gets the best out of students when he presents scientific facts to them on the basis of his own authority rather than as the shifting inferences from evidence. Why we think so, not just what we think, is the material of instruction. There is no one method of teaching, but its essence is to lead the student to want to use his own mind. It is a much more subtile thing than showing a student how to do a physical exercise, but I believe that an entire class should be taught in such a way that from the teaching itself the abler ones will of their own initiative desire to do research. Teaching in a professional school I should regard as advanced, not elementary instruction. Freedom within the course involves much; it means eliminating quizzes, eliminating all following of the student day by day to see if he has done this task or that; the student's work will be his own business and will be done at his own initiative. His note books and his records will be for his own instruction. In a word, such freedom will mean treating the students of a class as you treat research students, discussing ideas with them, suggesting plans of work, putting your greater experience to his advantage. In lieu of quizzes, a group of students could often be advised to organize and to run small clubs of their own in which they could look up and present work exactly as they will do later in professional life. If such a group had one or more members who were doing research themselves and would present it to their fellows, I should regard it as a great stimulus. The proper teaching of a course would give many suggestions of topics concerning which the students would themselves desire further study.

Freedom within the course, then, I should offer as a major subject for discussion in education. It is clear, I think, that, in a laboratory course, we can not mean, by freedom within the course, the utmost liberty on the part of each student to select his own material. Here he should be glad in the first place to profit by the teacher's greater experience. Moreover, a research student can have a degree of freedom with regard to material that is not feasible for a large class. There are two drawbacks that prevent such complete freedom for a class. The first of these is the work and the expense of preparing the material for a laboratory course. This is not true for the sections for a course in histology; they are usually cut in the summer months before the work is taken and could be given out to the student at any time. But it is true of the fresh, experimental material, which must often be used at exact times after it has been prepared and no laboratory can afford enough of the teacher's time or enough animals and materials to allow the student to follow his own sequence. Thus material in a laboratory forces the students to work on the same general topic at the same time. Secondly, no teacher is really equipped to lecture on a subject without fresh study and fresh reading each year. Everyone knows that we do not attempt to remember all the details of our subject, we know that one of the advantages for us in teaching is that each year as we take up each subject in sequence we find out what has been done in it, we study and think about it and above all try to formulate whether we can see some new opening to clarify it. Thus, from the standpoint of material and from the standpoint of the limitations of the teacher himself, it would be difficult to offer to large classes of students the liberty to choose the sequence of material to be studied within a course, but, recognizing this limitation, how much more important it is that he should have the utmost intellectual freedom in studying the material. It comes to this, then, that the liberty that is most essential in education is intellectual liberty, freedom of thought. Everything else is secondary to this. Dogmatism should be ruled out of teaching; the student should be made to see that a book is merely a record of what some one else has observed and thought about the same material that is offered to him for study and that the material itself is the safer guide. You will assuredly have some difficulties if you discuss ideas of intellectual freedom with students; if you tell them that it is more important to think than to memorize, for they will have some very specific experiences of examinations which were pure memory tests and for the most part they will discount your sincerity.

One of Dr. Mall's most favorite sayings was that an examination is more of a demonstration of a teacher's type of mind than a test of a student's ability. To quote Miall's again, "An examination paper should not be such that it could be handsomely answered by a candidate who had free use of a textbook. Papers of that sort are very common and encourage the verbal memory too much." What shall teachers do to counteract the reputation of their profession for dogmatism but to discuss liberty in education in the freest possible way, especially with their own students.

I wish now to discuss why I think that histology has become such an important subject in medical research. It is because histology has become the experimental study of the living cell. When we seek to trace this transformation in our subject we shall find that many influences have brought it about, but in evaluating the chief factors, I shall give first place to the introduction of the method of tissue culture by Professor Ross G. Harrison. As we all know, Dr. Harrison developed this technique for one purpose, namely, to analyze the nature of those remarkable processes that grow out from the cell body of the neurone, but the method has ushered in a whole new period in medical research. We all know of the application of this technique to mammalian tissues grown in plasma by Dr. Montrose Burrows working in Dr. Harrison's laboratory, of the further development of the technique and of the results attained by Dr. Carrel at the Rockefeller Institute, of the simpler technique of Dr. and Mrs. Warren Lewis, by which tissues can be grown in a fluid medium, which may not give as high a percentage of growth as the plasma method but which gives extraordinarily clear pictures of cells. There are many other factors in the transformation of this subject, the experimental embryology of Born, the study of living eggs by the biologists, the early study of living lymphatics in the tadpoles' tail by Dr. and Mrs. Clark, the study of living gland cells by Dr. Bensley, the introduction of the so-called vital staining by Goldmann, which has assisted in the experimental analysis of phagocytosis, the technique of supravital staining of cells and many other procedures. All these investigations have made a new subject out of anatomy, but they have done something much more important, they have broken down the artificial barriers between the different medical sciences. These things are not just the technique of anatomy but rather of all those who use the microscope. In the premedical sciences we had separated ourselves off into many groups for the purpose of teaching, on account of the development of different elaborate techniques; but we are now having a new realignment in the medical sciences. This realignment is actually taking place through a natural evolution in research; the type of problems which are being analyzed at the present time are obviously much more complex than those of a few years back.

Thus medical science itself is undergoing some such transformation as I have tried to describe having taken place within the one subject of histology. The great descriptive phase of medicine, when physicians were concerned with the classification of diseases, is drawing to a close; to-day we have as examples of major problems the nature of immunity, the analysis of how the cancer cell differs from the normal cell and the fundamental analysis of nutrition. It is directly in relation to such general phases of medical research, problems for research of interest to the whole body of the medical profession, that it seems to me that histology is playing a rôle. It is because, to use a specific example, one great phase of the subject of immunity is now specifically the experimental physiology of the different types of the cells of the connective tissues that the medical profession as a whole can with profit come back to the most ancient of its sciences, anatomy, for one of the newest of its scientific techniques. In actual research at the present time we have now in the premedical sciences not six separate scientific branches, but three great groups of workers, more or less distinct, on the basis of technique, those who use predominately the microscope, those who use the test tube and those who use the kinograph as a symbol of instruments for measuring mass action. Does not such a statement show how the barriers have already been broken down between the premedical sciences?

In the great period of the specialization and isolation of the sciences through which we have just passed we have developed a great elaboration of nomenclature. So complex has scientific nomenclature become that names rather than the actual complexity of the subject serves to wall off a given science from all other scientists. The complexity of nomenclature will certainly be one of the factors of greatest difficulty in the organization of the new project of biological abstracts. We must, it is true, have some specific names to be exact, but in the interests of the whole body of scientific workers in biology could we not insist that the titles of all papers should be so simple that any educated person might be able to tell what the paper is about, and the text so clear that any scientist could understand it? This would not involve giving up the exact terminology of science, but it would involve giving simple synonyms; for example, no anatomist can keep in mind all the names of zoology, but he is immensely aided just to know that carcinus is a crab. Let us get together on ideas rather than separate on nomenclature.

If you compare the titles of scientific articles in the journals of to-day with those of twenty years ago you will find that we are beginning to work in groups, often quite large groups. The nature of research is changing in such a way as to make this necessary. If you will allow me to illustrate from my own experience, Dr. Cunningham, Dr. Doan and I have been making some studies on the rhythms of the white blood cells. We have taken an individual and made studies of his blood every fifteen minutes all day long. Every fifteen minutes we have made a total count of the red cells, a total count of the white cells, a differential count of the white cells by the vital technique, a count of the platelets and of the reticulated red cells as well as a differential count of the white cells from fixed films. We have found that there is an hourly rhythm of the white blood-cells, that every individual covers the entire range of the normal number of cells per cubic millimeter, roughly, 5,000 to 10,000 cells each day, that the white cells are more numerous in the afternoon than in the morning whether the individual takes lunch or not, that the neutrophilic leucocytes have an hourly rhythm and die out in great showers in the circulation, that the lymphocytes have a shorter rhythm and do not die in the circulating blood to any appreciable extent and that the variations of the number of the different types of the cells are much greater than has been suspected and yet the rhythms are remarkably constant. It is quite obvious that such an experiment is entirely impossible without joint research; without a group of workers it would be left undone, in fact, we had considerable help beyond our group of three.

This is an example of joint research in which all use the same technique, but we are also having joint research between different groups. Perhaps one of the most significant examples in modern medicine of a joint attack on a major problem has been given us by the National Association for Tuberculosis in this country. A committee of that association has invited a group of workers in the different fundamental sciences to cooperate with them in an extensive study of tuberculosis; and this committee is showing the most far-sighted spirit of cooperation in putting the work of each division to the advantage of all the rest. It might be a matter of interest to us as anatomists that three of those who have been chosen for this work are members of this association.

Another most interesting example of such a correlation is to be found emanating from the chemists who have been studying rickets. The chemists have obtained cooperation of both histologists and clinicians with the greatest possible advantage to the solution of their problem. So many other examples could be found in the various institutes for research as to demonstrate quite conclusively that one of the most striking features in the research of our time is the development of cooperation.

The nature of joint research introduces a new factor to the problem of the training of students to become investigators. In my judgment the most successful method of training students in research in the past has been to start a student with a problem in which he could work by himself, could make his own specimens and analyze them; in joint research each one has to be a cog in the wheel during the time of the experiment; to put a student into such a group, to let him work with you on the general problem is really the time-honored method of the apprenticeship. That an apprenticeship has worked well in the arts, numerous examples of the student who has surpassed his master demonstrate, but I can not but feel that, though the method must often be accepted on account of the necessities of our problems, it calls for extra safeguards lest the student become a mere technical assistant and get no start in independent work himself.

There may be, of course there will be, personal difficulties in joint research, but certainly they will be no worse than our old scientific controversies. I have had some experience with scientific controversy, and in my judgment it is a poor technique. The flaw in it is this, that in controversy one seeks to convince one's opponent by argument and evidence that one's own theory is right and his theory is wrong. Now this is the exact thing that is not worth doing; because as long as a subject is growing, or in order that it may grow, it is of the utmost importance that people should be working on different theories. The worst effect of controversy is on the individual who takes part in it, because it tends to force him into contracting a marriage with his own theories; assuredly he should be in love with his theories, but he should never promise to remain so. Controversy is entirely different in spirit from the stimulating discussions between different workers that are the real basis for the formation of scientific societies. Herein lies a subtle difference in quality which may perhaps be expressed as follows: discussion stimulates while controversy depresses.

I offer then two topics for your consideration, liberty of thought in education and cooperation in research.

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RESTORATION OF THE OLDEST KNOWN FOREST

RESEARCH work carried on by the geological staff of the State Museum at Albany under the direction of Dr. John M. Clarke has resulted in the opening in that museum, on February 12, of a unique and remarkably realistic exhibit of a restoration of a forest of late Middle Devonian Age. Occupying a central alcove about 35 feet long, 30 feet high and 25 feet in depth, this exhibit has been rendered possible by the great wealth of fossil trees that, during the past four years, have been collected in the vicinity of the little village of Gilboa, N. Y. In 1869 a very heavy autumn freshet in the upper valley of the Schoharie creek in the Catskill mountains exposed a number of fossil tree stumps in the bed-rock close to the creek. The fossils collected at that time by Professor James Hall were submitted for investigation to Sir William Dawson, then principal of McGill University and the leading paleobotanist of his day. When one considers the character of the material he was called upon to examine, his observations were remarkably accurate, although he was unable to establish in detail the true nature of these trees.

Since 1920, excavations by the New York Board of Water Supply for the construction of a dam on Schoharie creek near Gilboa have exposed three horizons of erect fossil tree stumps within the sandstones and shales of that locality. At no other place in the world has there been discovered in rocks as old as these any approach to a similar abundance of fossil trees in such a remarkably complete state of preservation. From these three horizons, each of which is separated from the one next above by 60 feet of barren sandstones, there have been collected sixty or more stumps and many portions of the trunks, branches and roots of these trees, as well as their foliage, seed-bearing capsules and sporangia-bearing organs. At each horizon the more or less bulbous stumps, up to three feet in diameter, rise from black shales representing the rich soil in which the trees grew; in fact,