of the origin of a muscle from bone and fascia with its course and relations to its point of insertion. He must also learn the nerve supply of the muscle; but its action, which is the most important clinical feature, is usually ignored or at most mentioned casually.

The clinical teacher, on the other hand, ignores the minute description of its bony attachments, stressing particularly the action of the muscle, and noting especially the fact that some muscles, like the biceps brachii, extend over two joints and therefore have a more complicated action than muscles such as the brachialis, which acts on only one articulation.

The anatomical teaching of the vascular system of the body is also so complicated and minute that the student is forced to learn in parrot fashion the innumerable named branches of the arteries. Thus the external carotid artery is described as starting from the common carotid opposite the upper border of the thyroid cartilage, extending upwards and forwards and then backwards to a point behind the neck of the mandible, where it divides into the superficial temporal and internal maxillary arteries.

In its short course the external carotid artery gives off eight named branches, whose course and relations must be memorized. These eight arteries in their turn give off a total of thirty branches whose names must also be remembered by the unfortunate student. Is it any wonder that as a result of this difficulty every student is fortified by the series of rhymes which help him to remember the first letter in the name of each branch?

Some Modifications

In suggesting a few modifications in the teaching of anatomy in the preclinical years we must avoid the mistake of trying to teach the subject in a specialized form. The broad conception of anatomical structure must always remain. The student must be taught the interdependence of each system on the others, and all attempts to describe the subject as one of watertight systems must be resisted. It is wrong to suggest that a limited or first-aid course of anatomy would be sufficient to fit the student adequately for a medical career.

Nevertheless, there are some modifications which might be made in the anatomical curriculum, alterations which would not lessen the value of the course to the student and would make his subsequent medical training more simple. Of these suggestions the first and most obvious is the elimination of the uninteresting mass of detail which is of little practical clinical importance. The student should not be asked to take up a bone and map out by pencil or pen the exact limit of origin and insertion of every muscle and ligament to which it gives attachment.

To this suggestion the examiner holds the answer; so long as there is any possibility that he may be asked such detail the student must burden his mind with unnecessary material.

Further, there must be agreement between the clinician and the anatomist in regard to the amount of instruction which shall be given on pure anatomical grounds, as compared with functional and clinical details. It is unnecessary to teach all the details of muscular origin and insertion, but a sound working knowledge of these facts is necessary if the functional activity of a muscle is to be understood.

Much interest has been shown recently in the idea of instruction by means of radiographic demonstrations; these are of considerable importance in certain well-defined fields. Thus, radiographic pictures of the chest, abdomen, and joints are of considerable value, more especially in the case of the last-named in the recent innovation of movable

pictures, but we must realize the limitations of this method of instruction.

Modifications can also be made with advantage in the teaching of the arterial and venous systems. These are vastly important to the student and to the doctor, but there can be no advantage in knowing all the names with which the subject is at present burdened. The main vessels must be known and their situation and relation to other important structures and organs fully realized.

Central Nervous System

The teaching of the nervous system could also be altered with considerable advantage. With a full knowledge of the nervous system the student will be able to understand many of the problems which he will meet after qualification. It is not enough to teach a student that the deltoid muscle is supplied by the circumflex nerve: he must also understand the area of the cord from which these fibres are eventually derived, and know the other muscles supplied from the same segment.

Neurology, which to most students of clinical medicine is a difficult subject, is largely a problem of anatomical localization. The apparent difficulties disappear when the structure of the central nervous system is understood.

Too little use has been made of the important subject of developmental anatomy. Thus when instruction is being given on the structure of the central nervous system it is easy for the student to grasp the relationship and the possible abnormalities which may be seen in this system if at the same time models are shown illustrating the various stages of development.

Similarly, it is not sufficient that the student should read of the development of the heart or intestine without giving him the help which is gained from a study of models of these organs at various stages. The structure of fully formed bone can be understood more readily if the changes which occur in these tissues can be studied in models and diagrams.

Anatomy is one of the most valuable subjects in the curriculum; no attempt should be made to reduce its importance, but a more complete integration of anatomy with the clinical subjects is not a difficult problem.

ON TEACHING PHYSICS TO MEDICAL STUDENTS

BY

D. W. SMITHERS, M.D., M.R.C.P., D.M.R.

Professor of Radiotherapy, University of London; Director of Radiotherapy Department, Royal Cancer Hospital

An attempt by someone who is concerned with postgraduate education to evaluate the present teaching of the basic sciences to first M.B. students is beset with difficulties. While it is true that one should be in a position to judge how well the students from a number of different schools and from several parts of the world have been equipped scientifically for the work they have to do as doctors, one is also out of touch with the trend of thought in the undergraduate schools and with the plans for improvement in the training that are already afoot. What appear to be defects may be reasonable compromises hammered out after long discussion, and what seem to be obvious overdue reforms may only be awaiting the moment when they are no longer quite impracticable. Voluntarily to

undertake the task of teaching one's grandmother how to instil the physical principles involved in extracting the contents of eggs is extremely rash. The incentive is a firm belief in the need for more science in medicine. By this I mean a way of thought, an approach to problems, and not merely what appears to the lay public so often as a rather terrifying and uncontrollable technology.

The process of development of medicine from a mediaeval art into a modern science is proceeding. There is no knowing where important implications to medicine may appear at any time from advances in the basic sciences. The study of mechanics led the anatomists to advance their interest in form to include an interest in function. An obscure draper in Delft, through a persistent interest in lens-grinding, was the first to see an animal "a thousand times smaller than the eye of a large louse" in a drop of water, and so laid the foundations of bacteriology and histology. As in the past so to-day: the introduction of artificial radioactivity in providing a new method of investigation by tracer techniques has started a new era of medical research.

The reason for inviting a radiotherapist to write about the teaching of physics is presumably that radiotherapists are so clearly concerned with the application of physics in medicine, and that they have been foremost in recognizing the need for the appointment of hospital physicists. Radiotherapists are not, however, alone in their interest in medical physics, the place of which is hardly given adequate recognition by astonishing statements such as the following which appeared in a leading article in the *British Medical Journal* in 1945: "At present the application of physics to medicine is limited to radiology, the electrocardiograph, and the encephalograph in diagnosis, and the somewhat empirical use of various forms of radiant energy in treatment; but it is highly unlikely that these represent more than a fraction of the contribution physics might make to human biology."

Physical methods of diagnosis and treatment have become indispensable in medicine and have so expanded in recent years and have covered so many branches that it was possible to publish in the United States a year before the above quotation was written an encyclopaedia of medical physics of 1,744 pages under 255 main headings listed in the table of contents (Glasser, 1944). The extension of the employment of physicists in general hospitals only awaits an initiative in other clinicians similar to that shown by radiotherapists; in fact, the latter have already established physics departments in most large hospitals which are ready and are waiting to be called on.

Educational Value of Physics

The importance of physics in medicine and the fact that the teaching of first-year students has been unable to keep pace with the advances cannot be seriously disputed. Before we judge the success or failure of present methods of instruction, however, we must have a clear understanding of what we want to achieve. It is all too easy to point out how much more is required, and all too difficult to reconcile the claims of the many subjects which compete for time on the already overloaded medical curriculum. If every sectional interest had its way years might be added to the training of the poor medical student, who only wants to be a doctor. The reason for teaching him physics should be to help to make him a good doctor first and to provide him with an appreciation of the practical applications of physics in medicine second. We should not forget, in considering the first, that technical ability may be an important

professional quality and, in considering the second, that so many branches of medicine are open to each individual student that he is unlikely to deal personally in practice with more than a small fraction of the physical methods concerned. Teaching that does not help the student towards these ends should be ruthlessly eliminated on the grounds that the inclusion of any unnecessary work under the present conditions of strain in a medical education amounts to cruelty.

Anyone in daily association with a large and active department of medical physics employing nine physicists may be forgiven for stressing the importance of the practical application of physics in medicine, but no one who also consults with a number of doctors about the treatment of patients with cancer could deny the paramount importance of a sound general scientific education. The advancement of the practice of medicine demands that doctors receive a thorough training in the scientific method of logical, objective, dispassionate thought. To teach a medical student that the field of human knowledge is expanded by reason and experiment; that he should remain unmoved by plausible argument while retaining the capacity to accept new ideas, and so depend upon his own judgment; that when his facts are verified and his arguments tested he should proceed to apply his conclusions fearlessly—this is an achievement which rises far above the mere provision of technical proficiency.

Those combinations of qualities which go to make a good doctor and which are so hard to define are enriched and given purpose by a scientific outlook. The dissection of a problem to its fundamentals, the correlation and interpretation of the available facts, the conclusion uninfluenced by personal bias, add point both to the skill with which he applies his treatment and to the understanding and fellow-feeling that soften his conversation with his patients. We have too many fashions in medicine, too many new remedies which work wonders for a while, too many specialists whose diagnoses always lie within their specialty, and too many medical advocates of quack "cures" on the basis of one or two cases unusual in their limited experience but well within the bounds of normal variation.

It is reported (Shryock, 1948) as an example of the sad way in which treatment used to be based on mere assertions of the most dogmatic sort that Fréteau, in the early nineteenth century, insisted on the necessity for venesection in certain conditions "on the ground of *two reported cases*, each susceptible of other interpretations than those he accepted" (the italics are not mine). Why pick on the nineteenth century when 1949 would do as well? We do not have to go so very far back in the correspondence columns of our medical journals for equally good examples. Doctors are not always less susceptible to convenient illusions than their fellows, nor are they less ready to produce rationalizations to preserve for themselves their appearance of reasoned thought and logical action. The laudable desire to save the medical student from some of the rigours of the syllabus, to get down to "the fundamentals of medicine" and away from all this "pure physics," must not be allowed to interfere with his essential, basic scientific education. Physics and mathematics are particularly valuable as a background training in scientific thought and method.

Medical Physics

Having insisted on physics for its basic educational value, must we therefore necessarily insist on a course of classical physics similar to that planned for the elementary training of physicists? Surely a greater concentration on medical

physics will serve our purpose just as well and at the same time add interest and practical advantage. The undergraduate should learn to appreciate the use of physical methods in medicine and acquire a basic knowledge on which to build should he later take up some branch which is closely associated with a particular form of medical physics. It may be as well that the basic sciences should not seem to be too well defined; medicine has no interest in artificial barriers between the sciences, and physical chemistry and biophysics cannot be ignored because they have been arbitrarily placed on some borderline. We shall certainly not solve the real problems of the lengthening syllabus, the urge to get on with the things that will be useful, and the need to eliminate the inessential by insisting on the *status quo*.

Once the student has embarked on his medical career the continuation of his scientific education should surely be made an integral part of his training rather than a preliminary to it. The medical student sets out to do medicine; he regards a good deal of what he is taught in his preclinical course as being divorced from this object. It is too often merely an obstacle in the path of his progress towards matters of real interest. He has to-day to overcome considerable difficulties to be allowed the opportunity to start at all, and at this stage is eager for instruction in subjects that seem to him to have an obvious medical application. When you start out to heal the sick it is a little discouraging to find yourself confronted by a Wheatstone bridge and a post-office box.

Dr. Henry Yellowlees (1946) starts his admirable and delightful book with the sentence, "I suppose that the most significant, if not the most memorable, day of a medical student's career is that on which he finally emerges from the preclinical period, and I have always felt that the occasion of his first introduction to clinical work might well be marked by some appropriate ceremony." I think that this is a true picture of the position, but it contains some reflection on our method of presentation of the basic sciences as medical subjects.

Adjustment of the Syllabus

Postgraduate students embarking on a physics course for a diploma in medical radiology can be heard one after another denying familiarity with the physics that they were taught so few years before. No hospital physicist "assumes a knowledge of physics equal to that of the first M.B." whatever the regulations may say, because he knows from sad experience that he can do no such thing. This is some indication of the failure to ensure that the training does at least consistently provide a sound though elementary knowledge of physics. Is it possible that the reason so many retain so little is that their interest was not engaged; and could the general educational result have been achieved with medical physics of more interest to the student and a greater degree of usefulness to him during his clinical training?

If we assume that the present methods do achieve their main object of developing a scientific outlook and promoting a way of thought, giving due allowance to the varied abilities of the students to absorb such teaching, then reform must be cautiously applied to see that none of this is lost. If we assume that they do not achieve even this end, then reform is urgently needed. There would seem to be some reason for doubt whether the present arrangements of the teaching of physics are in fact nicely adjusted to produce the desired result. No emphasis is placed in the syllabus on the development of the all-important

attitude of mind; this is left to take care of itself in the general classical approach to the subject that is laid down, or rather is left to the individual teachers on whose varying knowledge of the needs of medicine and whose ability to impart an outlook to the student all ultimately depends. Some, at least, seem concerned only with the elementary details of heat, light, sound, electricity, and magnetism.

The practical utilitarian side of the instruction appears shyly here and there in the syllabus with the mention of osmosis, spectacles, microscopes, ophthalmoscopes, radioactivity, and thermionic emission. That no real importance is attached to these concessions to those who have demanded more direct application of the prescribed syllabus to medicine is shown in the list of exemptions which allows a boy from school to avoid all such instruction. The introductory paragraph of the syllabus of the University of London for "Physics (including Mechanics)" does not say, "The subject is to be treated as a basis for the development of a critical, reasoning, scientific outlook and illustrated as frequently as possible by means of direct practical examples of the applications of physics in medicine; a knowledge of mathematics on the part of the student is an inestimable advantage in attaining this object, the experimental approach being the only other method likely to be successful." Instead there appears the rather dreary sentence, "The whole subject is to be treated in an elementary manner, the mathematical development in no case extending beyond a knowledge of quadratic equations and elementary trigonometry."

It has, I believe, been suggested that the first M.B. might be abolished and that instruction in chemistry, physics, and biology be given along with that in anatomy and physiology in one preclinical course. More time is wanted for the second M.B., and it is thought to gain it at the expense of the first. The time would presumably be gained by the elimination of much of what is now taught in the basic sciences and regarded by some as unnecessary, and what remained would be more closely related to practical, everyday medical needs. If every student received a sound scientific training at school, if anatomy and physiology were not allowed to swamp the chemistry, physics, and biology that remained, and if teaching were done imaginatively and largely by the experimental method, using direct clinical applications for illustration, there would be much to be said for the suggestion. The student would start off doing something more nearly related to medicine; he might better appreciate the need for the physics he was being taught. There are, however, a lot of "ifs" concerned. I do not know how such an arrangement would work, but while fundamental changes are being discussed there are still reforms which surely should be made at once.

Suitable Instructors

The teaching of physics to medical students should never be solely in the hands of a university physics department, but should include instruction from those with personal practical knowledge of the medical applications of physics and who themselves engage in research in physics in relation to biology or medicine. There is a growing band of hospital physicists available who would benefit from a closer contact with medical students and also from the necessity to review the applications of their branch of science to medicine on its broadest basis. There should be no exemptions from a course of this kind. Hospital physicists could produce many fascinating subjects for inclusion in it. Some knowledge of radioactivity, of the use of

radioactive isotopes as tracers in the investigation of physiological and pathological problems, and of the use of a Geiger-Müller counter as a clinical instrument are obvious examples. It is not difficult at the same time, for instance, to convey something of the potentialities of the quantitative method, something of present ideas of the nature of the atom or the ways in which experimental confirmation of theory has been obtained.

Last year I was fortunate enough to see the results of an exercise set by Dr. Joseph Hamilton to a student class in the University of California at Berkeley in which each student was required to set down in detail an account of an experimental investigation that he would like to carry out with a radioactive tracer material and that had not been suggested before in the literature. Nearly all were reasoned, practical, original suggestions, and some were so well presented and of such merit that the opportunity of carrying out the experiment was being provided to these students. It would be hard to find a better example of the use of a method of applied medical physics as a means for promoting a scientific outlook. It is difficult to believe that such a result could be obtained with the methods of training students in operation in most schools in this country at the present time.

Practical Applications

Illustrations of the application of physics in medicine naturally occur to me primarily in the field of radiation, but many others can be found. Some of the applications of optical principles, such as the measurement of erythrocytes by the haloes they cause around a source of light, or microscopy from the optical microscope to the fascinations of the electron microscope, where a virus may be shown by means of a golden shadow, are good examples. Electronics is invading medicine on a large scale and provides possible demonstrations for the student in such varied fields as neurophysiology, the measurement of radiation, the use of hearing-aids, electrocardiography, muscle-nerve stimulation, colorimeters, pH meters, and even the demonstration of surgical operations by television.

An obvious illustration in surgery is the importance and means of counteracting the physical factors that interfere with respiration and circulation when the chest is opened. The dermatologist may be interested in the physical forces which produce alterations in skin pigment, the psychiatrist in electric-shock therapy, the ophthalmologist in the spectral sensitivity of the various parts of the retina and the methods of investigating night-blindness, the haematologist in electrophoresis, the orthopaedic surgeon in the trajectories of stresses in bone, and the otolaryngologist in the complications of vestibular mechanisms.

The difficulty is not to find illustrations but to distinguish amongst the wealth of material available those most likely to hold the student's interest and provide him with an appreciation of the underlying physical principles concerned, while unobtrusively developing his powers of critical examination of a problem and his desire and ability to test a theory by experiment—in fact, providing him with the capacity for logical, impersonal, objective thought.

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Nova et Vetera

SIR WILLIAM GOWERS

Sir William Gowers. By Macdonald Critchley. (Pp. 118; illustrated. 17s. 6d.) London: William Heinemann Medical Books. 1949.

Dr. Macdonald Critchley's life of Sir William Gowers, who was born in 1845, records the chief events of his career, illuminates them with the reminiscences of those who were privileged to be his pupils, and reviews his contributions to medicine. He was born the son of a Hackney shopkeeper, and it was probably the accident of his father's early death and his widowed mother's migration to the neighbourhood of Oxford that set his foot on the first rung of the educational ladder at Christ Church College School. An apprenticeship to a general practitioner in Essex was his entry into the profession to which he was destined to contribute so much. Thereafter University College Hospital and subsequently the National Hospital made up the sphere of his activities. He played no great part in medical affairs: neurology filled his working life, and hobbies, especially shorthand, occupied his spare time. He died in 1915.

Gowers will be remembered as a great clinical observer. Dr. Critchley points out that the early descriptions of many of the nervous diseases which we recognize to-day with confidence are due to his acumen. That this has not been more generally recognized in the past is due to the fact that many such descriptions were given casually in the course of his writings and it was often left to subsequent observers to attach a label to conditions which Gowers had discovered.

Dr. Critchley has written a valuable memoir which is short enough to make the reader wish for more. Ten illustrations add to its interest, and it includes a bibliography.

RUSSELL BRAIN.

PIONEERS IN ORTHOPAEDICS

On the Contributions of Hugh Owen Thomas, Sir Robert Jones, and John Ridlon to Modern Orthopaedic Surgery. By H. Winnett Orr, M.D.; supplement by Arthur Steindler, M.D. (Pp. 253. £1 5s.) Oxford: Blackwell Scientific Publications.

These three men, prominent in their generation, have added much to orthopaedic surgery, and a critical examination of the work of any one of them would be sufficient to satisfy most writers. Dr. Orr has wisely not attempted to judge the value of all their contributions to orthopaedics, but has confined himself largely to Thomas's writing on rest, and the reactions of Jones and Ridlon to these principles. It is for this reason that Jones and Ridlon appear not as original workers themselves but rather as pale moons reflecting the light of the sun. The book enables the reader to obtain a picture of the relations between the three men, and it brings to the notice of the profession once again the great advances made by Thomas and the difficulties he encountered.

Dr. Orr's style of writing leads on occasion to some difficulty. He does not finish his remarks on one personality before discussing others, and this results in a certain amount of confusion which could readily have been avoided. He rightly criticizes the many modifications and improvements of the Thomas splint that have been suggested during and between the two world wars, and states that it would have been preferable if the authors of these suggestions had learned how to use the splint in the correct manner. Directly after this condemnation Dr. Orr explains that "the use of skeletal fixation pins (not wires) in plaster of Paris represents the only substantial improvement in the technique for maintaining correct length—position—and rest—since Thomas himself."

It is unfortunate that with a subject in which the facts could be so readily confirmed there should be a few obvious mistakes. For example, Thomas was not trained by his maternal uncle Owen Roberts, of St. Asaph, at the Liverpool Workhouse Hospital, as stated in the text, and it is obvious that Dr. Orr meant Sir Astley Cooper and not Sir Ashley Cooper. It is hard to define the exact character of this book; it includes many extracts from other authors and follows closely their opinions.

T. P. McMURRAY.