with physiological knowledge as will provide the best foundation for his study of practical medicine and for his life's work. Several powerful warnings have recently been uttered, by Dr. C. M. Wilson and Dr. J. A. Ryle among others, against the growing danger to the student, in the mass of facts which he must endeavour to swallow and hold ready for disgorgement in the examination room. Even if such "fact-cramming" were educationally good, practical considerations must set a limit to the time available and thus to the total volume. There is abundant justification, however, for the plea that the real object of the medical curriculum, perhaps more than of any other educational discipline, should be to train the student to observe, to think, and to form a reasoned judgement, and not to make confused and evanescent records on his memory. It is easier to see the difficulty than to see the remedy. If we were concerned only with the training in physiology of men who would find their careers in teaching and advancing that science, the difficulty would be great enough. Within one generation the volume of well-established knowledge, in the range of physiology alone, has undergone a manifold multiplication, and even the advanced student of the science for its own sake is in danger lest his power of thought and of intellectual enterprise should suffer from the strain on his memory.

But the problem is far more urgent in the case of a man who will pass on, from a brief study of physiology, to courses of practical medicine and surgery, ever more crowded and complicated by the inevitable new growth of special lines of discipline and of practice. Some, I think, would seek a remedy in pushing back the commencement of the practical training, of work in the ward and the theatre, into the earlier years of the curriculum. It seems to me that the condition must indeed be desperate if this can be regarded as its remedy. A proper claim could be made for physiology, rightly presented, as pre-eminently fitted for training the mind in the conditions of accurate observation, in the meaning of quantity and measurement, in the putting of questions to Nature and the appraisal of the answers obtained. To the student it gives his first opportunity of bringing the ideas and standards derived in his earlier studies from chemistry and physics into clear relation with those from biology. It makes him face, for the first time, the problem which lies at the foundation of all medical practice, as well as of all physiology—that of interpreting physical and chemical data in relation to the special uncertainties and complexities imposed, in the present state of knowledge, by the nature of a living organism. We could claim for it, I think, a pre-eminence in that truly educational function, the danger to which in the growth of the medical curriculum has been so justly lamented. If physiology, however, claims this high function, as I think it can, it must be prepared to make whatever adaptations are needed for its fulfilment, in relation to the needs of the medical student and to the limited time at his disposal. I cannot claim any right to speak on details, for there are few physiologists with less experience than mine of the practical difficulties and possibilities of teaching. There is much, no doubt, to be said for the movement in recent years, in many schools of physiology, towards replacement of many of the older practical exercises, some of which had more historical interest than educational value, by such experiments and observations as can be made directly on the human subject. Provided that the course continues to train in the broad methods and aims of physiology, as the experimental science of life, it is all to the good that the student should thus early make contact with the peculiarities and difficulties of observation on man himself; but it is immensely important for medicine, as well as for physiology, that the latter should not allow itself, in the education of the medical student, to be reduced

to the role of a mere technical training in methods which will find their practical use in the wards. Provided that physiology holds firmly to its special and supremely important part in medical education, there must be room for variety of individual choice of matter and method by teachers, in accordance with their own special interests and capacities. Selection will, in any case, be necessary, and will have to be determined to some extent by the direct needs of the later curriculum. There are items both of fact and of method in physiology which the student of medicine must acquire for their bearing on aetiology, diagnosis, or treatment. But the important, and increasingly difficult and responsible task of the teacher of physiology, as I conceive it, is to incorporate these in his selection from the overwhelming riches of established physiological fact and suggestive physiological evidence, and yet to retain for the student the full educational value of this, his first and principal chance of contact with a purely experimental study of the phenomena of life.

The problem of to-day's discussion is no new one to physiologists. Such change as has taken place in the relation between physiology and medicine, within my own memory, seems to me to be unquestionably in the direction of improvement. The new interest which has recently led to its more public discussion is due, I believe, not to any new urgency of the problem, but to recognition of a new phase of it, which is in itself a sign of betterment. We have surely moved far from the position in which, as a student entering the wards some thirty-two years ago, I was told that my first duty was to forget physiology, which had no relation to medicine. The danger now is not that we should ignore or repudiate the relation, but that we should find and advocate a wrong one. We are witnessing a natural and, in the main, a healthy development. In friendly discussion, amid differences of opinion and experience, we shall surely find some common ground of effort for its promotion and guidance, in the interests of physiology and of medicine alike.

THE RELATION OF CLINICAL MEDICINE TO PHYSIOLOGY FROM THE STAND- POINT OF RESEARCH *

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The relation between physiology and clinical medicine might be treated from a number of distinct and interesting points of view, but my remarks will be confined to their relation from certain standpoints of research work. This subject has long interested me deeply owing to the intimate contacts I have enjoyed for many years with both these sciences. The occasion is one which obviously affords an opening for compliments to physiology. They would be compliments easy to make and it would give me great pleasure and satisfaction to utter them; for my admiration for the advances physiology has made in recent times and for the great and beneficial influence it has exerted upon medicine is unbounded. Though it would give me personal gratification I do not see that it would fulfil a very useful purpose, for both physiologists and clinicians are already well aware of the services that physiology has rendered and continues to render to medicine. I feel sure, if what I say to-day includes little direct praise of physiology, if for once it gives clinical medicine the prominent place,

*Read in opening a discussion in the Section of Physiology at the Centenary Meeting of the British Medical Association, London, 1932.

that my physiological friends will recognize that my sympathy and esteem for physiology remain unabated. In speaking of the relation chiefly from the standpoint of medicine, what is said is dictated by the developments of recent times, which call me to pursue an idea that expresses a great need of the present day. It is that clinical medicine should make a determined effort to take its proper place as a progressive science on an equal footing with physiology. And I look confidently to physiology for the support which I know it will generously give, on every occasion when it can do so, towards the accomplishment of this purpose.

MUTUAL INSPIRATION

Although this aspect will not be dealt with at any length I cannot refrain from placing first the statement that physiological work forms and must continue to form a great stimulus to clinical medicine. The fact is universally acknowledged and I pay my own homage unreservedly to it. When it is said, as it often has been said, that modern medicine is being built upon a foundation of physiological knowledge, an undeniable truth is stated. Abnormal phenomena that we observe in diseased subjects must be interpreted usually as interferences with normal function, and therefore in terms of normal function. But, as there will be further occasion to notice, this is only a fraction of the truth. While clinical medicine draws inspiration from physiology, so likewise physiology draws inspiration from clinical medicine. Physiology has benefited greatly in the past, and continues to benefit still in two ways; first because a very large proportion of physiological work is directly or indirectly suggested by clinical problems; and secondly because clinical workers in their search for explanations of the abnormal phenomena, which they witness, often themselves become heavy contributors to physiological knowledge.

The most obvious illustration, and one which will serve the double purpose, is that of Harvey and his work. Harvey has been called the "Father of Physiology," but Harvey was a physician. The fact that there were no pure physiologists in those days, and that Harvey might be regarded as representing physiology in his time, is irrelevant to the point that is being made. I am using this great physician's work as an illustration of how contact with patients inspires and leads to research upon the normal functions of the body; it is a perfect illustration of how clinical medicine can react upon related science; in this instance actually beginning to form a science. Whatever else Harvey did he undoubtedly discovered the systemic circulation; and it is very apt here to point out that this discovery in particular, and the more complete statement of the circulation into which he wove it, was based in very large part upon experiments carried out upon the human being, the first object of research to which a physician naturally turns.

To illustrate from modern times presents no difficulty.

The origins of our knowledge of the chief ductless glands and of growth factors in food were clinical. The work of Henry Head upon normal sensation was prompted throughout by clinical observation. Finally, to cite an example of less direct contact, the brilliant physiological researches of our president (Sir Henry Dale), which have led up to the discovery of histamine and acetylcholine as normal and probably most important products of tissue activity, began in a search for the active principles determining the therapeutic action of the remedy ergot.

At the moment two chief objects are in view; in the first place to emphasize the importance of research upon phenomena witnessed at the bedside, so that young men of ability may be helped to realize, or supported in their belief, that the clinical field of work is a most fruitful

field, not subservient to but often guiding physiology; and to show that it is most important to the welfare of physiology that clinical medicine should be strong.

THREE IMPORTANT BRANCHES OF MEDICAL RESEARCH

A statement that medicine is founded upon physiology is, as has been said, but a fraction of the truth. There are vital branches of clinical knowledge to which physiology contributes little if at all. There are three chief ways in which clinical progress is achieved, and these may be reviewed briefly. They are: (a) the discovery of disease, that is the identification of disease and its natural history; (b) experimental work on clinical cases; and (c) the application of physiological ideas and discoveries. The third of these is in fact the only one that is fully relevant to our discussion to-day; but it is impossible to obtain a clear view of the relations of clinical medicine and physiology without understanding all.

(a) *Discovery of Disease*

This term is used more because it is convenient to my purpose, than because it is accurate. It is a phrase standing for the clear description of specific diseases or states, so that these may be identified unmistakably for what they are by others. The method here used is chiefly though it is not exclusively observational, and it is comparable to the isolation of specific species in biology. Studies relating to the cause and meaning of a disease or state, studies relating to its treatment, can scarcely begin until the first step is taken, until the identification of the disease or state has been accomplished. It is a vital step, but its importance is frequently overlooked by those unfamiliar with clinical methods. This matter may be brought home perhaps most readily by reviewing the history of cardiac diseases during the last thirty or forty years. The practical management of cardiac diseases has changed and has improved remarkably during this period of time. What then have been the chief discoveries leading to these changes, which have been as great and beneficial as those occurring contemporaneously in any branch of medicine or surgery? Many still harbour the notion that a chief advance has been the analysis of cardiac mechanism, beginning, if this is fancied as the proper starting point, in Gaskell's work on the frog and tortoise heart. It is impossible to acquiesce in this idea. In so far as the mechanism of the heart is concerned, the chief advance has been the successful subdivision of different irregularities as these are exhibited by human patients, coupled with the subsequent study of the natural history of these irregularities and of the action of remedies upon them, which was rendered possible by this subdivision. This work was independent of the final analysis of disordered mechanism, in the sense that it did not require that analysis; in actual fact it outstripped the analysis of disordered action in almost all important instances; it was carried to completion in many, could have been carried to completion in all, instances without the analysis. Thus, the chief practical discovery of our times, the almost specific action of digitalis in cases of gross irregularity of the heart, was accomplished by James Mackenzie's splendid work long before we knew this irregularity to be due to auricular fibrillation. And the discovery that it is due to auricular fibrillation has been responsible for little or no change in the treatment of the disease either by digitalis or by quinidine. The isolation of the irregularity due to auricular fibrillation from other irregularities was purely a clinical discovery and unprompted by physiology; it could not have been anything but a clinical discovery. The isolation of this and other irregularities, with the natural sequence, namely, the rational use of digitalis and

the allied drugs, has been perhaps the most revolutionary change in the management of heart cases in recent times ; and the benefits that have been derived from it are now incalculable ; they unquestionably exceed the benefits that have been derived from the discovery of insulin, owing to the far greater prevalence of auricular fibrillation as compared with diabetes.

It is possible that the discovery named should not occupy the first place ; it may be that other discoveries now to be named will prove of equal or greater consequence ; it matters little from our present point of view, for these are also clinical and not physiological discoveries, and could not be otherwise. I name the life-history of that protean disease rheumatic fever as it is now known and the great additions that have been made to our knowledge of the times and ways in which this disease invades the heart. It is to be remembered that rheumatic fever is the chief cause of heart disease. I name the identification of subacute bacterial endocarditis, of coronary thrombosis, and if the years may be a little extended backwards, the recognition of hypertension in man and its consequences, as also amongst the chief discoveries of modern times leading to changes in our care of cardiac patients. Most if not all of these clinical discoveries would have been made in almost exactly the same form had there been no contemporary physiology. In discussions relating to the characters of discoveries the word "fundamental" is often used. Using the word in its accustomed sense we may say that the discoveries I have named are fundamental to clinical science.

(b) *Experimental Work on Clinical Cases*

In an article written a few years ago I had occasion to indicate that progressive medicine can cling too exclusively to be fertile to the observational method, by which is meant the simple witnessing and recording of spontaneous phenomena ; but that it must adopt more widely and use more carefully the experimental method. It is self-evident that the observational method, most fruitful as it has been even in recent times, must through mere exhaustion become less prolific, whereas the experimental method whenever it is applied to biological science is found to open up new channels of progress. I have since seen no reason to change this view, though my remarks have been read by some with insufficient closeness and in consequence have sometimes been misinterpreted.

The misinterpretation arises out of a wrong understanding of the word experimental, which has come to be associated too exclusively with animal experimentation. The two methods, observational and experimental, are of course closely interwoven and a useful purpose is not always served in attempting to separate them. In experimenting we make observations, not upon events that are happening quite spontaneously (observational method), but upon events that are provoked or influenced by the interference of the experimenter. The method is by no means new to medicine. Many physical signs that are used clinically are won not by purely observational methods but by experiment. If a muscle is stimulated by an electrical shock and it is noticed to respond, that is an experiment. If a tendon is struck sharply and the knee-jerk results, that is also an experiment, and one that can be undertaken under a variety of conditions controlled by the observer. Tests that are employed to identify and isolate diseases are becoming more experimental as time passes. Therapeutics has always been and always will be almost purely experimental in its method ; but it has not always adopted the full precautions of what has come widely to be called the "experimental method." My plea is that these experiments, inevitable as they are,

should be conducted in such fashion that the result does not remain in doubt, they should be controlled as experiments are controlled in a physiological laboratory. Such controlled experiments will mean to the individuals, upon whom they are undertaken, a little sacrifice of time and perhaps of comfort (it goes without saying that they must entail no risk) in order that the observations on the few may benefit the many. That there may be no possibility of further misunderstanding of this important matter one or two of the precise examples that I had originally in mind may be cited. About twenty years ago a patient was admitted to hospital suffering from rapid ventricular action due to a fibrillating auricle. He was put to bed but was given no digitalis until ten days had elapsed. This was done to ascertain if, and by how much, simple bed treatment would lower ventricular rate ; and to avoid the pitfall of attributing to digitalis an effect for which it was not responsible. It was desired to ascertain precisely what the effect of digitalis was in such a case, and the withholding of digitalis for a preliminary period was necessary to arrive at the true answer. A physician so acting, though acting with the highest motives, could not be said to be "preoccupied" by solicitude for his patient. Regarded purely from the standpoint of an isolated patient the withholding of that drug, even for a few days, is not easily defensible ; from the standpoint of inquiry into the best means of administering digitalis to many future patients no other plan would seem to be defensible.

If I have under my care a patient with Heberden's angina of effort, and I ask that patient to do in my sight what he is in the habit of doing daily, namely, to walk a given distance ; and I do it so that I may ascertain precisely how far and how fast he must go before he begins to feel pain ; if I now induce him to repeat this test under different conditions of my choosing, as before and after administering to him nitroglycerin, then I am clearly making full use of the experimental method. And in this manner information is gained about the action of the drug, which is valuable not only in the general sense but to the particular patient upon whom the tests are made. Such experimental work, in the hands of those fully realizing their responsibilities for the welfare and well-being of their patients, is playing an increasingly useful part in progressive medicine. It is a method which, properly employed, is full of promise. It is sometimes referred to as the "physiological method," but that is a loose phrase, and dependent simply upon the accident that physiology makes of it such abundant use. There are certain methods of work that are suitable and common to all biological sciences, and whether work is carried out in ward or in laboratory. The experimental method belongs no more to one field of work than to another ; and in parenthesis it may be said that the use of the terms "ward methods" and "laboratory methods," in so far as it implies that the methods are essentially distinct, is to be deprecated. There is but one method and that is the true method, and it is applicable equally in ward or laboratory. But my main purpose here is to indicate that clinical medicine has its own proper field of experimental work and that in this field it is not borrowing from or leaning upon physiology. It is work essential to the progress of practical medicine. It is work that is carried out upon patients suffering from disease ; it can be undertaken only by clinicians, and these should be clinicians having special facilities and training, and having judgement to know how far experiment is consistent with the complete welfare of the patient.

(c) *Application of Physiological Ideas*

The great contribution of physiology to clinical medicine, is the help it gives us in understanding the mechanism of

disease, allowing us, as previously indicated, to interpret disease in terms of altered function. Thereby our conceptions of disease are brought to greater exactitude and we are enabled to regard the phenomena displayed by our patients more rationally; the gain to accuracy of thought ultimately influences medicine profoundly. From time to time, too, a laboratory discovery, by supplying a necessary link, leads almost at once to a therapeutic discovery manifestly of first-class importance. The discovery that insulin enables the tissues to utilize sugar, and that a substance in the liver may regulate the formation of red blood cells, will at once come to mind. What is now added is in no way intended to disparage the importance of these laboratory discoveries. They are of the highest importance. But if the matter is left at that stage the relation of physiology to medicine, as illustrated by such instances, will be left only in part explored. The use of insulin for diabetes, the use of liver extract for pernicious anaemia, has not depended purely upon laboratory experiment. A first and vital step in each case was the discovery, the isolation and clear description of the disease concerned—and, incidentally, in each case this knowledge of the disease reacted favourably upon correlated physiology. A last and vital step in each case consisted in the testing of what might perhaps prove to be a remedy upon selected patients. Thus, the therapeutic end-result was accomplished by a chain of work and that chain was forged of links, some clinical and some physiological, but each and all indispensable to the integrity of the chain. In such cases the emphasis often comes to be laid almost wholly upon one of the links and this a physiological link. Perhaps this is natural, but it is not always quite reasonable. That it is not always reasonable is shown by the fact that the high praise for the physiological link does not always come immediately but awaits the clinical link or application; evidently in such instances the praise is not based upon the intrinsic merit of the physiological discovery but largely upon its end-result. In appraising the merit of laboratory work too much stress is often laid upon the end-results to which the work leads; actually the application of his work is not often foreseen by the worker himself. It is not his deliberate design, except in the sense that he may safely assume that all knowledge will at some time become applicable; but if that is an inevitable circumstance, it is one for which the worker is not responsible. When a physiological discovery is applied to medicine, the application is in fact clinical, and it is not infrequently beset with difficulties equal to or even greater than those of the original physiological discovery; to clinical science therefore the credit of the application should go in full. If as sometimes happens the physiological element of the discovery is selected for undue praise then the importance of the clinical contribution tends to be overlooked, to the discouragement not only of the clinical workers concerned, but of clinical as compared with physiological investigation.

Let us, however, put this question of the apportionment of credit on one side, and look at the matter more broadly and without placing physiology and clinical medicine in rivalry. The whole position is summed up so it seems to me in a few sentences. Knowledge that is to be applied usefully to the health of mankind will almost always come by a series of steps, the first of which is the recognition of the human need, the last of which is the application of a test directly to the human problem. It is in the nature of things, however many steps may intervene, that the first and last must be clinical; as it is also in the nature of things that almost all important physiological discoveries that are immediately applicable to the treatment of disease have their original source in clinical observations.

CONCLUDING REMARKS

It has here been indicated that there is vitally important work, appertaining to the study of human disease, that can be undertaken only upon patients and by clinicians. It seems unwise unduly to prolong the emphasis that it has become the habit to lay upon laboratory contributions, and especially physiological contributions, to medical science. When physiology was struggling for independence and for position, this emphasis served a useful purpose and left clinical science unembarrassed. But physiology is now in a much stronger academic position than is clinical science and is overshadowing it. The stress laid upon physiological discovery is due in part to the fact that the full importance of clinical science is not recognized by those who are inclined to see in physiology more of the basis of practical medicine than physiology actually provides. It is wrong, and it is a misfortune, that young men, whose life-work lies in clinical medicine, should be brought to feel that clinical is less fruitful than physiological research; or that they should be forced to think that they can win their spurs as research workers only in the laboratories and not by work on patients. An over-emphasis of one branch of physiological work plays a particular part here. This most fruitful branch is over-emphasized because it has become necessary to defend it in the justification of animal experimentation; but the position it so often takes in the public limelight is inimical to the best interests of medicine as a whole.

It is most desirable, if they are mutually to inspire, encourage, and help each other, that clinical science and physiology should pull abreast in the team of medical sciences; it is clinical and not physiological science which now needs the stimulus to a new and more vigorous alignment. Clinical science must possess itself of a phalanx of research workers of ability and full training, who will hold the fort for this branch of medicine, build up again its scientific prestige, and maintain its privileges in a manner that those engaged in the busy routine of daily practice cannot hope to accomplish. There are benefactions and bequests to medicine that are sometimes made in such terms that they are undoubtedly intended for clinical research, for the "discovery of disease"—a first and essential step as we have seen—towards the study of its cause and towards the alleviation and cure of disease. Such benefactions tend to become deflected to physiology and this tendency is probably inevitable—I am not sure that it is not desirable—until clinical science can enforce its claims by sheer merit. The successful enforcement of the legitimate claims appears to depend chiefly upon the establishment of suitable posts in clinical research and the formation of a group of full-time workers, who can hold their own in method of work and of scientific thought with workers in any other branch of medical science, and who are prepared to devote their lives to the study of disease without forethought of practice, and to the consolidation of that branch of science which is their own. The kind of training that is desirable for men aspiring to such full-time posts, the facilities required for their work, I have already attempted to outline in an earlier address.¹

Finally let it be clearly stated that what is in mind is not a separatist movement from practical medicine, but a linkage between this and physiology and pathology, through a body of workers who have the necessary training and sufficient leisure to understand and apply the knowledge these sciences are gaining, and to interpret them to those whose energies are devoted to the arduous task of recognizing and alleviating the troubles of sick people. The linkage, as I indicated many years ago² and as I still visualize it, is largely through human physiology.

REFERENCES

¹ *British Medical Journal*, March 15th, 1930.

² *Ibid.*, November 15th, 1919.