An Address

ON

THE RELATION OF PHYSIOLOGY TO
MEDICINE, IN RESEARCH AND
EDUCATION*

BY

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We are engaged in a meeting which commemorates the foundation, one hundred years ago, of an association whose members, in overwhelming majority, are engaged in the practice of medicine for the prevention and healing of disease. It seems to be fitting that we of the Section of Physiology, if I may here for brevity use that term to include both physiology and biochemistry, should turn aside from our normal preoccupation, with the advancement of physiology as a science, to consider its relation to the practical aims of medicine, and its proper part in the training of those whose lives will be given to pursuing these aims. I suppose that a hundred years ago few would have thought of physiology as a science separate from the study of human anatomy, or of either as anything but a part of medicine. Physiology, indeed, together with the whole of experimental medicine, began in the modern world with the work of a court physician, William Harvey. In the following century, it is true, some of the major contributions to animal, as well as to plant, physiology were made by an English clergyman and student of pure science, Stephen Hales. But in general physiology did not begin to be thought of as a science separate from medicine until relatively late in the nineteenth century. Until Michael Foster went to Cambridge in 1870, as praelector of physiology in Trinity College, the only teaching of physiology in that university was given by the professors of medicine and surgery.

Foster had been a pupil and assistant of William Sharpey, professor of physiology in University College, London, a centre to which British physiology, as we now know it, can trace so much of its origin through Foster, Burdon-Sanderson, and their successors. Through the schools which thus arose British physiology entered upon a development which had started a generation earlier in France and Germany, under such leaders as Claude Bernard and Carl Ludwig, as a separate discipline of study and research, retaining an essential part in the training for medical practice, but acquiring a progressive independence in the choice of its ways of approach to its central problem of the nature of vital phenomena. Of such cleavage from a parent science or discipline physiology provides, of course, only one example among many. Botany and chemistry first came to be studied in relation to the medicine of much earlier days, and each long ago achieved a more complete independence than physiology has yet attained. Their separation, however, provides, at best, a distant analogy; in spite of their medical origin, botany and pure chemistry could only retain a restricted and peripheral contact with the field of medical science and practice, while physiology, investigating the phenomena of life itself, must always remain the central core of the knowledge required by medicine. A nearer analogy is presented by the relation of physics to the science and practice of engineering. In any case, this budding off of independent sciences and specialization of scientific activities is a phenomenon common to science as a whole; it is most active at the points of rapid growth,

of which it is the inevitable consequence. We cannot stop the process anywhere, except by stopping or restricting the advance of science itself at some point. It is vain, if natural, to look back, with an envious regret, to the days when the whole range of scientific knowledge could still be mastered by one human intelligence. Each new specialization of knowledge and activity involves, for a group of investigators, some narrowing of scope and interest, and risks for them the loss of fertilizing contacts. This, however, is the price which we pay for progress, and our only rational aim is not to obstruct its advance, but to keep the price as low as possible.

This inevitable evolution, which must render an increasing range of physiological inquiry independent of medicine, will produce, in different observers, reactions which differ in accordance with personal experience and interest. It may well be that Lord Moynihan, who twice in recent years has deplored what he terms the "truancy" of physiology from medicine and surgery, gives expression to an opinion held by many. The attitude is one which physiologists must recognize and consider with close attention, but our response to it will largely be determined by our interpretation of its meaning. If it merely voices discontent with the degree to which surgery and medicine are retaining contact with, and gaining new powers from, the advances of physiological knowledge, let us agree that fuller co-operation is still a pressing need in the interests of physiology itself, as well as in those of medicine and surgery, without assuming that the defect is either new or increasing, or that blame for what is lacking here lies wholly on the shoulders of physiology. If it implies, however, that the daughter, physiology, should resign her freedom and return to a perpetual and exclusive service of the practical aims and needs of her parents, I think that we must firmly dissent from such a Victorian conception of filial duty, so harmful to the independent vigour of the parent as well as to the free development of the new generation.

VALUE OF THE RELATIVE INDEPENDENCE OF PHYSIOLOGY

It seems to me beyond doubt that this acquisition of a relative independence by physiology and by the other experimental off-shoots from medicine, and, in the case of biochemistry, from physiology itself, enabling each to follow any clue to new knowledge without immediate and constant reference to a practical aim, has already achieved far more for medicine than would have been effected under a permanent parental control. It is difficult to choose among the examples which crowd upon attention; we may be content to look at two, which have been quoted in connexion with an advocacy of the opposite view.

Discovery of Insulin.—Diabetes was discovered by clinical observation, and was known to medicine for some centuries before the clue to its nature was obtained as the chance result of an experimental investigation undertaken for a widely different purpose. Von Mering, being interested in the physiology of the digestion and absorption of fat, asked his assistant, Minkowski, to attempt the complete removal of a dog's pancreas. The operation, being successfully performed, had the unexpected result of producing great hunger and thirst and the output of large volumes of urine loaded with glucose. Minkowski followed the chance clue and proved that the condition so produced was in practically all respects identical with the diabetes mellitus of man. It is obvious, of course, that this recognition involved a knowledge, built up by many years of clinical observation, of the main characters of diabetes in man. But can anyone suppose that physiological experiment undertaken with the particular object of finding the cause of diabetes, and taking its clues and directions entirely from the wards, would have been

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likely to lead even to a suspicion that the pancreas was concerned?

Further progress to the present position has, at every stage, depended on knowledge drawn from the general body of experimental physiology and biochemistry. The production of artificial pancreatic grafts showed that the influence of the pancreas on carbohydrate metabolism was due to an internal secretion, comparable to those which experimental physiology had been demonstrating for other glands of hitherto unknown functions, and that it came from a part of the pancreas not concerned in forming the digestive juice. Then followed successive attempts to prepare the hormone in stable form for artificial administration. Many failed, no doubt, through ill luck in the choice of methods for trial, but I think there is little room for doubt that some would have succeeded, if their authors had only been able to use the means for recognizing success. Biochemistry had to find good methods for the rapid estimation of glucose in small samples of blood, for example, before the testing of pancreatic extracts became a practical possibility. To say that success, when at last it came, was achieved by use of all the knowledge and resources which had only then become fully available, and that it represented the well-placed top stone on a structure of which Minkowski had laid the foundation, and which had steadily risen by the labours of others too numerous to mention, is not to weaken, but greatly to enhance, the credit due to the Toronto workers. It means that their discovery effected a sound advance, of immense scientific as well as practical importance, on one of the main fronts of experimental physiology, and was not merely the result of a chance throw. Physiology rejoices with medicine in the immediate application of the result, for the dramatic relief of a crippling ailment; but physiology was giving its best filial service to medicine, not only at the stage which brought this therapeutic triumph, but in the labours of all who, without the immediate lure of practical success and popular acclaim, had patiently sought, through many years, the knowledge which made possible the ultimate achievement of insulin.

Surgery of Sympathetic Nervous System.—Let us take as one other example the relatively recent extension of surgical intervention to the sympathetic system. It might have been supposed that there were very few fields in which physiology could more justly claim to have provided a great body of detailed and exact knowledge, ready and waiting for the use of surgery and medicine, as soon as these should have sufficiently advanced in the refinement of diagnostic analysis and of operative technique to be able to find its practical applications in the treatment of human disease. From Claude Bernard's first demonstration of the vasomotor function of the cervical sympathetic nerve, through the work of Ludwig's school, and later and most conspicuously through that of the Cambridge school of physiology—Gaskell, Langley, Anderson, to mention only those whose work is already ended—down even to the present day, there has been no more absorbing subject of detailed and intensive investigation by physiologists than that of the varied functions of the sympathetic and other autonomic nerves, in controlling the activities of the involuntary muscle coats and gland cells of the different organs of the body. Little, if any, of this work was undertaken with a direct view to its medical or surgical application. At any stage it would have been easy to represent a particular item as truant from the service of medicine. I cannot doubt that its comprehensive range and its detailed accuracy, and thus its ultimate practical value, would have suffered if it had been so directed. That does not mean that physiologists were without hope of seeing their hard-won knowledge of the structure and function of this special

system provide a scientific basis for medical and surgical advance. On the contrary, I think it is true to say that they waited with a disciplined patience, recognizing all the obstacles imposed by the primary concern for a patient's interests, knowing something of the technical difficulties to be met, but confident in the ultimate use, in dealing with man's ailments, of this exact knowledge of sympathetic functions in his humbler relatives; confident also that such use would bring for physiological knowledge not only a practical fruition, but a reflex enrichment from the knowledge of these same functions in man, which only medicine, and especially surgery, could give.

Two years ago Lord Moynihan, hailing the fact that surgical enterprise had at last entered a field so long and so diligently made ready for it, regarded the event as proclaiming the somnolence of physiologists. In his recent Romanes Lecture, so full of stimulating thought on the relation of advance in medicine and surgery to general scientific development, and so clear in its defence of experiment on animals against ignorant attack, he still suggests that surgery might not have needed thus to delay for a generation "if Gaskell's and Langley's work had been more accessible to clinicians." Physiologists will not readily accept either imputation, and I am confident that they will have no desire to cast any in return. The work of Gaskell, Langley, and their pupils, like that of all physiologists, has been made accessible to those with time and interest to study a plain but stimulating record. Physiologists are alert and eager for the new knowledge which will surely come from the progress of surgery in this and other fields. Their danger lies not in apathy but rather in the temptation to apply to surgical evidence, in generous allowance for its natural limitations, a standard less critical than that which they demand for their own. Physiological knowledge will certainly be enlarged by recognition of the differences in detail between the normal functions of man and those of even his nearest animal relatives, and by the observation of phenomena which require the co-operation of a patient for their detection. But if new conceptions are to displace or to take equal rank with those which the deliberate and controlled investigations of a generation of physiologists have created, they can only do so on evidence which will pass as severe a scrutiny. We can be open-minded and eager without lowering our standard of criticism. To maintain it is one of the highest duties which we owe to medicine and surgery, as well as to physiology; and we shall be somnolent indeed if we let it fall.

PHYSIOLOGISTS AND THE STUDY OF PHYSIOLOGY OF MAN

No unwillingness to allow physiology to bear the whole blame for what may be amiss will prevent us, however, from recognizing the fact that freer contact and greater readiness of co-operation on both sides are needed for the healthy development of medicine and surgery, and of physiology itself.

Looking back over my own relatively short experience, I find no reason to suppose that physiologists in general have diminished their concern with the physiology of man. I think there are clear signs, indeed, of a definite tendency in the opposite direction. It would be unsafe to found a general conclusion on individual examples, but it is difficult not to find some significance in the contrast between a Burdon-Sanderson, in an earlier generation, coming into physiology from medical practice and devoting the remainder of his active career to an academic study of the electrical reactions of cold-blooded organs, and a worker like A. V. Hill, in our own time, coming into physiology from physical chemistry and mathematics, and applying, in direct investigations on human muscular activity, the knowledge gained by earlier study of the

energetics of isolated frog's muscles. Dr. Douglas will no doubt make mention in our discussion of the great body of investigation on human physiology which has grown up in Oxford round John Haldane, with an influence spreading not only to every centre of physiological research, but to every progressive clinic in the world. These are merely two out of many possible examples which could be cited against the suggestion of a growing neglect of human physiology. I do not think that there is any reason to believe that lack of direct physiological experiment on man has been responsible for widening the gap between medicine and physiology, or, indeed, that the relation of human physiology to medicine must of necessity be closer, or of greater practical importance, than that of much experimental work which, from its very nature, could not itself be carried out on man. Can we imagine a progressive neurology not rooted in the experimental physiology of Sherrington, of Magnus, of Adrian?

CHANGE IN THE RELATION BETWEEN WARDS AND LABORATORIES

It would be difficult, further, to support a suggestion that medicine has failed, in general, to make use of the new weapons for accurate diagnosis and rational, specific treatment, which have arisen in imposing succession from work in the experimental laboratories, often from work undertaken without any such immediately practical aim. The present century has seen a remarkable revolution in practice which has largely transferred the initiative, in the discovery of new methods of diagnosis and treatment, from the wards to the laboratories. To mention only a few scattered items which spring to the mind: the use with x rays of substances rendering organs artificially opaque to them; methods of measuring metabolism and respiratory exchange; methods of micro-analysis for the various constituents of the blood; the conception of endocrine deficiencies and the use of extracted hormones to replace them; vitamins, and their relations to the causes and treatment of diseases; salvarsan and other agents of specific chemotherapy; serums, vaccines, and the whole apparatus of active and passive immunity—these and innumerable others have been direct gifts of the laboratories. And the danger, the present defect of co-operation, arises, it seems to me, not from unreadiness in the laboratories to give a practical turn to physiological discovery, or from unreadiness of medicine to apply what the laboratories have been able to give. If this were the co-operation needed, we could be satisfied, I think, that improvement is steady and progressive.

The real danger, I believe, lies rather in the very success which has appeared for a time to come from this division of function, and the resulting tendency for medicine and surgery to regard experimental research as the function of physiology and pathology, and the acceptance and application of its results as the function of medicine and surgery. Division of function and specialization of activity are the inevitable conditions of progress, but physiologists will not claim, and will not be willing to admit, that the right line of cleavage is here. They recognize, without any desire to criticize or to impute blame, that other circumstances have favoured the growth of such an unnatural division. They have seen that devotion to research, which in their own careers is expected to bring promotion and wider opportunity, may have entailed for a clinical colleague a surrender of natural ambition; and they welcome the signs that influences powerful in medical research, such as the Rockefeller Foundation and our own Medical Research Council, have been, and are being, steadily exerted for the removal of such anomalies. By none has the need been more clearly seen and stated than by Sir Thomas Lewis, who

will follow me, and to whom I can leave its further discussion. Let me only voice the welcome which we give, as physiologists, to the movement among some of our clinical colleagues of the newer generation, making them ready to embrace the opportunities, now opening, for careers of single-minded devotion to the quest for new knowledge in the clinical field. For to physiologists it seems clear that the proper relations between physiology and medicine can only be attained when conditions have been created which enable medicine and surgery to rise to the full height of the opportunity which general scientific progress has presented to them; to use and to apply, indeed, such methods and principles as physiology can give, but especially to find and to create for themselves those which they will need as independent and progressive experimental sciences. Only thus, I believe, can they use to the full what physiology can offer, and give to physiology what it requires for its own development.

With all reserve as to the many imperfections of any analogy from one group of sciences to another, I may cite again the relation of physics to engineering in all its aspects. Does anyone suppose that engineering would have gained by claiming that all physical investigations should be directed to the solution of engineering problems, or by criticizing, as truancy from this proper duty, all those researches into the fundamental nature of matter and radiation which are one of the great glories of our age? Physics and engineering, as separate but closely co-operative experimental sciences, each recognizing the need of the other and the proper differences between their immediate aims, have produced a still progressive revolution in our conceptions of the material universe and in the mechanical structure of our civilization. Neither physiology nor medicine will help the progress of the other by attempting to impede the differentiation which is a condition of progress. What both require is a frank and respectful recognition that their immediate aims and their proper spheres of activity must be different though not exclusive, and that each will gain by progress in the other, as an independent, though intimately co-operative, experimental science. Speaking as physiologists, we may recognize that the progress of our work may on occasion be stimulated by its extension from the laboratory to the wards, without assuming that our only, or even that our best, contributions to medicine will thus be made. We should welcome, on the other hand, a more frequent entry into our laboratories of the physician or the surgeon, when his investigations need what we can offer, but we should not suggest that this is his only, or even his most effective, means of contribution to the great fabric of medical science.

PHYSIOLOGY IN THE MEDICAL CURRICULUM

Thus far we have considered the relations between medicine and physiology as departments of medical research. We meet, however, as a section of an Association consisting chiefly of those whose opportunities for adding to medical knowledge, in a life devoted to the practical application of what is known, can be but rare and unorganized. The relation between physiology and medicine which most concerns them, and especially those who will succeed them, is the part of physiology in medical education. This forms, of course, only an aspect of the wider and always more urgent problem of the overcrowding and overloading of the medical curriculum, which again is another result of the development which, in the field of research, has entailed a progressive specialization. It cannot be doubted that the growth of medical knowledge will ultimately entail a great extension of specialization in practice. Meanwhile, however, it is the task of the teacher of physiology to find means of giving, to the student destined for general practice, such contact

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,

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