SCIENCE

VOL. LXVIII SEPTEMBER 21, 1928 No. 1760

CONTENTS

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal.

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

THE RELATION OF PHYSIOLOGY TO OTHER SCIENCES[1]

OUR subject of physiology has developed so rapidly during the last few decades, has taken so definite a place among the sciences and has such intimate relations with other subjects, that its position as a branch of natural knowledge is one of some general interest.

Physiology has a threefold appeal—as the master-key of medicine its practical value is self-evident, as a science it has now a distinctive position, while its relations to philosophy command the attention of all thoughtful men. We will consider it, for convenience sake, from these three standpoints.

From the earliest times, physiological knowledge, whether known by that name or not, has had the closest association with medicine. It would indeed be difficult to imagine any great advance in the one that was not immediately reflected in the other. Their methods, though necessarily different, are convergent, their meeting-point being the disclosure of normal functions. It is the business of the physician to attend to the urgent call of pain and disease, and to use for their relief such information as he has at his disposal. As he does so he observes, compares and draws conclusions on the basis of which a theory of the causation of the disorder may be built. The clinical observations and deductions drawn from them give a basis of rational physiological theory from which we have learnt that a state of disease is never a thing in itself, but is always a result of a quantitative change in some physiological process, an increase or diminution of something that was there to begin with. Reflection upon the observed bodily states in, say, a fever, jaundice, diabetes, nephritis or even mental disorders, reveals only overaction or underaction of some physiological function as the feature which distinguishes the affected from the normal individual. It is perhaps easier to speak of the normal than to define it. In the long run, the normal is the description given by a majority of individuals of their own build or behavior. It is abnormal to have unequal legs, to be eight feet high or to believe the earth is flat; but as no two individuals are exactly alike the definition of normality is more a matter of a statistical average than of precise definition.

[1] Address of the president of Section I.—Physiology. British Association for the Advancement of Science, Glasgow, 1928.

Disease is a departure from the normal which threatens life or which in some way reduces its value. The physician's duty with regard to it is a threefold one; he must diagnose, prognose and treat. In diagnosis and prognosis he relies chiefly on past experience, and must also bring great skill and judgment to bear on each particular case. The symptoms of disease which enable him to make a diagnosis are very often of an adaptative or compensatory nature, and the application of physiology to the problems of medicine is often of considerable value from this point of view, since it teaches that the mere alleviation of symptoms may be quite the wrong way to attack the problem. In cardiac or renal dyspnea, for example, the exaggerated breathing is of an adaptative nature —the patient is not ill because of the overbreathing, but overbreathes in consequence of the disease and would possibly succumb if he did not. More usually the meaning of symptoms is less clear, and it is the difficulty of recognizing the underlying causes of disease which makes the practice of medicine at once so exquisitely difficult and so fascinating.

In treatment, too, two important principles arising from actual observation receive support from physiological knowledge. One is that the consequential alterations which take place in the course of the disease are of the nature of adaptations which tend to restore the function to normal; these adaptations take the form of increase or diminution of some particular factor, of hypertrophy or atrophy often of some definite organ, always of some function—it is, in fact, the *Vis medicatrix* of the older physicians, the underlying principle of expectant treatment. The other principle is that nearly all positive measures of treatment, including drugs, produce their effects by augmenting or restricting some function or other.

The applied aspects of physiological knowledge concern the related subjects of hygiene and preventive medicine, medicine, surgery and veterinary and agricultural sciences in their widest senses.

Investigations on diet, ventilation, industrial fatigue and on the contraction of and resistance to infections, soundly based on the fundamental principles of physiology, have done much to make conditions of life more tolerable for the present generations than for their predecessors. Few medical students at the present time become acquainted with those severe or fatal cases of rickets, scurvy, diabetes or pernicious anemia which we all knew could be seen in the wards of any large hospital twenty years ago, and this gift of life and health to the afflicted is the grateful offering of physiological research to its respected parent, medicine.

No aspect of scientific activity is so generally misunderstood as that which concerns the making of discoveries, and in matters of medical research ignorance is particularly widespread.

The popular idea seems to be that an investigator sets out with the intention of making a particular discovery, such as a new element, or a cure for a certain disease, but every scientific worker knows that real discovery, as distinct from invention, is never achieved in this way. A discovery is the process by which an idea of new relationships is revealed, and involves two factors, observation and reflection. The origin may be a chance observation which suggests a hitherto unappreciated relation, and leads to the formulation of a hypothesis which, if possible, is then deliberately tested by experiment. The history of the discovery of insulin may be given as an illustration. The fundamental discovery here was made by a chance observation that removal of the pancreas produced diabetes; from that time onwards it was evident that if the missing pancreatic function could be replaced a cure would be possible, and it was justifiable deliberately to search for some means of doing this. But the search was in vain until another new idea came into physiology by reason of the discovery of the existence of autacoids. From this point on all was clear in theory, and it is no detraction from the merit of subsequent work to say that the final happy result depended principally upon inventive technique and manipulative skill, and only in a lesser degree upon discovery.

Discoveries are infrequent, in a sense fortuitous, and often dependent on rare qualities of intellect as well as on accurate observations, and they mostly come out of the fullness of time.

We all feel great pride in recalling that one of the greatest of all discoveries, which has recently been celebrated at the tercentenary of the publication of William Harvey's famous book "*de motu cordis*," was made in our own country. Here was a genuine revelation that put old facts in a new light. It is of interest to reflect that the hospital at which Harvey was a physician had been carrying on its work as such for over 500 years at the time his discovery was made. What fundamental changes in the outlook of the physician and surgeon has that hospital seen during the ensuing 300 years in consequence of his revelation! And what further mutations in thought and practice will it have witnessed when Harvey stands as a beacon half-way in its eventful history? For we are privileged to live in times pregnant with opportunity for the science of medicine.

Incidentally it has been claimed, with more audacity than insight, that experiments upon living animals serve no useful purpose, and it has even been pretended that Harvey had no need for such experiments in the classical researches which formed the foundations of physiology and gave reason to physic. Yet we have Harvey's own words. . . . "At length, and by using greater and daily diligence, having frequent recourse to vivisections, employing a variety of animals for the purpose, and collating numerous observations, I thought that I had attained to the truth, that I should extricate myself and escape from this labyrinth and that I had discovered what I so much desired, both the motion and the use of the heart and arteries."

The experimental method, which was revived by Harvey, now forms the permanent basis of physiological as of medical knowledge, and in spite of all criticisms must obviously remain so. Riolan, in advancing against Harvey the criticism that "it is a mockery to attempt to show the circulation in man by the study of brutes," was, as Gley has recently remarked, "already employing the argument, if it can be called one, which is encountered under the pen of the antivivisectionists of all times, and which illustrates the diuturnity of ignorance and folly."

Let any one with sufficient acquaintance with physiology try to write an account of such of the main facts concerning the functions of the heart and of the circulation as are most valuable in medicine, without reference to any fact obtained directly or indirectly by animal experimentation, and he will find his essay a very sorry one indeed: for no doctor can use a stethoscope, feel a pulse, take a blood-pressure, administer a hypodermic, give an anesthetic or a transfusion, perform any modern operations or indeed take any steps in diagnosis, prognosis or treatment, without utilizing at every turn knowledge derived from the results of animal experimentation and obtainable in no other way. And every medical man, even those few who for various reasons prefer the publicity of an antivivisection platform to the obscurity to which they are properly entitled, knows these things perfectly well, and if he practices, acts upon them every day of his life.

Another useful application of physiological knowledge is that of the science of ventilation, including the use of mine rescue apparatus, which began to take shape during the eighteenth century in the hands of Stephen Hales, while a little later Joseph Black, a professor, be it noted, of medicine and chemistry in this ancient University of Glasgow, discovered carbon dioxide, and Priestley oxygen. The use of submarines, of oxygen sets for aviators and mountaineers, of gas respirators and caissons and the means for the scientific study of industrial fatigue and of athletic performances, have all descended as practical outcomes of this respiratory physiology.

To take another example in more recent times one may mention Joseph Lister, a cherished link between University College, London, and the University of Glasgow, that indefatigable experimenter who made as valuable contributions to physiological knowledge as to surgery. The revolution in surgical technique which we owe to his largely physiological investigations is as striking as the changes in the outlook of medicine introduced by Harvey. Erichsen, a teacher of Lister, had said not long before that operative surgery had reached the limit of its perfection and that the surgeon's knife would never safely penetrate such parts as the brain, chest or abdomen.

The subject of pharmacology is very closely connected with physiology, on the one hand, and therapeutics, on the other. As a branch of physiological work it has the highest scientific as well as practical importance; for the study of the mode of action of drugs by providing a means of studying the effect of definite chemical alterations in the environment on the reactions of the living cells can not fail to serve as a powerful instrument of physiological research. Rational therapeutics, based on the results of pharmacological study, also will carry into the wards the spirit of true scientific investigation, and the provision of beds in some hospitals for the use of the professor of therapeutics is an indication that definite progress is being made in this direction. Such an advance has not come before it is needed. If the medical practitioner is to compete successfully with osteopaths, chiropractors and other similar unqualified persons, he is most likely to do so by only prescribing treatment with proper scientific basis. He should be able to form some opinion with regard to the claims of advertisers of remedies who contribute so large a share towards his daily mail deliveries, and many of whom would be unable to exist were it not for the fact that the average doctor is often as easily deceived with their pseudo-scientific puff as any layman.

If physiology may with pride point to the way in which it has contributed to the development of medicine, surgery, hygiene and veterinary science, it must with gratitude acknowledge that its inspiration has largely come from them too. A clinical friend of mine has written that "physiology can only come to the aid of medicine with becoming modesty, and without overweening dogmatism. There is no finality about either, but they can cooperate usefully . . ." and I thoroughly agree with him, not only because I recognize, as a physiologist, that my subject has been nourished largely by the problems of the bedside, but also because I think that modesty is the only attitude compatible with the ignorance of all of us when we view the handiwork of nature however revealed.

At this point I should like to digress a little to say a few words about the training of medical students in physiology. This has two objects in view, first, to equip these students with a grasp of physiology such as will enable them later on to build a proper rational knowledge of medicine and surgery; second, to encourage them further to advance medical and surgical knowledge, and in special cases physiology itself. With certain reservations, I do not think that these two objects are at all incompatible at the present time.

A hundred years ago the common portal of entry into the medical profession was by a preliminary apprenticeship, begun at the age of about fourteen, to a doctor or apothecary, as often as not in the country. This lasted for five years, after which it was usual for the student to "walk the hospitals" at some great center, the chief in London being St. Bartholomew's and Guy's Hospitals. Here he could also attend some lectures on anatomy (including physiology), botany, medicine, surgery and midwifery and there were also courses of dissections. The requirements of licensing bodies were, however, fragmentary. The College of Physicians had no definite curriculum of professional study before 1845. In Scotland physiology was incorporated, as the "Institutes of Medicine," with some teaching of general pathology and elementary clinical medicine.

The medical students of Dickens—for example, Bob Sawyer, who "eschewed gloves, and looked upon the whole something like a dissipated Robinson Crusoe"—were caricatures of the students of this period.

There were few medical students in England outside of London a century ago; Oxford and Cambridge together averaged six medical graduates a year. Edinburgh produced about 100–120. In England it was only the handful of university men who received anything like a preliminary education before entering the hospital.

A notable step was taken in London with the foundation of University College, then called the University of London. In his introductory address at the opening of the university in 1827, Sir Charles Bell said: "With respect to our students, the defects of their mode of education are acknowledged on all hands. They are at once engaged in medical studies without adequate preparation of the mind; that is to say, without having acquired the habit of attention to a course of reasoning; nor are they acquainted with those sciences which are really necessary to prepare for comprehending the elements of their own profession. But in this place this is probably the last time they will be unprepared, for example, for such subjects as we must touch to-day. In future, they will come here to apply the principles they have acquired in other classrooms to a new and more useful science."

In the first year 165 students entered the new college, and classes were held in chemistry, zoology, anatomy (and physiology) and on various clinical subjects.

Jumping forward now about forty years to 1867, we find the curriculum has expanded very much. First, there came the influence of Liebig and chemistry, and by about 1850 or 1860 we find chemistry, mostly inorganic, a regular requirement by all licensing bodies. A chemical laboratory was first constructed at St. Bartholomew's for instance in 1866. The University of London now required at a preclinical examination a knowledge of chemistry, botany, natural philosophy, anatomy, organic chemistry, physiology and materia medica. A contemporary writer gives an account of the students of this period from which it appears that the medical student has since changed more in appearance than in ways, for he says that the principal aim of some of them was preservation of their glossy hats and exquisite coattails, gloves and sticks, while the throwing of paper balls was already an established tradition among them.

Although lectures on physiology are mentioned at this time, there was no separate chair of physiology in England until 1874, when Sharpey, who had been professor of anatomy and physiology at University College, was succeeded by Burdon Sanderson as the first professor of physiology. The first practical classes in physiology were held there by a pupil of Sharpey, Michael Foster, and consisted of histology, experimental physiology and rudimentary physiological chemistry. To quote Foster's own words, "What could be done then was very, very little. I had a very small room. I had a few microscopes. But I began to carry out the instruction in a more systematic manner than had been done before. For instance, I made the men prepare the tissues for themselves. That was a new thing in histology. And I also made them do for themselves simple experiments on muscles and nerves and other tissues in live animals. That, I may say, was the beginning of the teaching of practical physiology in England."

We realize from these dates that physiology in Britain had fallen very far behind when compared with the Continent, for Ludwig, in Germany, who obtained a separate chair of physiology in 1865, and Claude Bernard in France, had raised the subject to a high level by the time that physiology in England was being reborn, through the activities of Sharpey and his pupils, Foster and Burdon Sanderson.

The teaching of physiology is, very properly, largely influenced by contemporary research work, and the exact matter taught must, therefore, be expected gradually to undergo change as the focus of research interests shifts.

It was only natural that the new English physiology should receive the stamp of the men who recreated it, and that histology through Sharpey, and nerve-muscle physiology through the influence of Burdon Sanderson, should occupy a prominent place. For about thirty years in fact the nerve-muscle physiology threatened to eclipse all other branches of experimental work, and it was this flight into questions which appeared to be chiefly of academic interest which was, I think, largely responsible for the regrettable estrangement between the newly liberated science and its parent subject of medicine which marked that period of its development, and of which traces still linger to this day in some of the more elderly representatives of both subjects. At the present day we must admit that the knowledge gathered by those of our predecessors who worked at the physiology of muscle and nerve has proved of great value in directing physiological inquiry along scientific lines, from which the science of medicine has profited as much as physiology itself. The interesting revival of the study of the same subjects by more accurate methods within the past few years has further enriched our insight into the fundamental phenomena of life and vindicated the opinions of our predecessors as to the value of such investigations.

The development of physiological chemistry, now often called biochemistry, in this country was largely due to the influence of Professor W. D. Halliburton, whose "Chemical Physiology and Pathology" was for many years the only comprehensive English textbook on the subject. The growing importance of organic chemistry led to its introduction into the medical curriculum, in connection with biological chemistry, and in recent years the similar position of physical chemistry has led to its inclusion in some form or other in the curriculum of most medical schools.

Whereas in the sixties the student's chief study was anatomy with some botany and chemistry, there have now grown up as special courses of instruction, each with its professor or other specialized teacher, courses in the preliminary sciences and in anatomy, neurology, histology, embryology, organic chemistry, physical chemistry, physiology, experimental physiology and biochemistry, with pharmacology often thrown in as a makeweight to fill up any spare time the student may have left. Sometimes even special courses of human physiology are added. Here is the great dilemma of the medical curriculum: with all these special departments, each urging that its subject is of prime importance in the course, how can the poor student rightly direct his steps, and be enabled to see the wood for the trees? Yet, so great is the expansion in each of these subjects, that unless some at least of them are dealt with by specialists the student's instruction will unquestionably be obsolete in parts.

The solution to the difficulty lies, in my opinion, in two directions: first in the extensive modification of the present system of examinations, and secondly in the exercise of a sympathetic understanding on the part of specialist teachers of the difficulties of the student and a proper perspective of the relation of his own subject to the requirements of the curriculum as a whole. We have a sacred trust: it is the duty of those of us who are teachers of physiology to hand on to our successors, not the science as we inherited it, but a science which we and our contemporaries have ourselves improved and enriched to the best of our ability.

Out of the multitudinous and tumultuous activities of scientific labor new principles gradually emerge, and the truth appears in a constantly changing garb. As I have said before, research reflects itself in teaching, and it is accordingly necessary that teaching should be reviewed from time to time, that new matter be introduced in so far as it is of general importance, and old matter rejected as soon as its immediate value diminishes. I should very much like, for similar reasons, to see profound alterations in the teaching of chemistry, both inorganic and organic, to medical students.

It is, in my opinion, quite impossible, and perhaps undesirable, at the present time to frame instruction in physiology so as adequately to equip the ordinary medical student to proceed directly to the prosecution of research in any of its branches; this can only be achieved by a further year or two of study of the subject, such as by a science course for an honors degree. One of the objects of instruction is to enable the latest results of physiological investigation to be utilized in the clinic, and it seems to me that one of the best ways for this to be effected is for some workers specially trained in physiological methods to enter the staff of clinical units where facilities for research work are at hand. The opinion was at one time prevalent among many clinicians that if their problems required the use of methods similar to those of experimental physiology these should be farmed out to a physiologist, and although there are cases where this procedure may be followed with advantage, the rich harvest which has already been reaped by the importation of physiological knowledge and methods into, rather than the export of problems from, the clinic, is adequate justification for the former. It is in any case encouraging to note the present-day decline of the attitude that experimental investigation is work of a lower order, which can be put out like so much washing, for the employment of an inferior caste. We at the present day, however we may be labeled, are not merely willing to admit, but eager to assert, that we can not recognize fundamentally distinct methods of physiology, of psychology, of medicine, of chemistry or of physics; we only admit a method of experimental inquiry common to all science and slightly modified to suit particular cases.

The close connection which is now generally admitted between physiology and medicine was clearly foreseen by Claude Bernard in 1855. Medicine, he said, is a science, and physicians who describe it as an art injure it, because "they exalt a physician's personality by lowering the importance of science." "True experimenting physicians," he says, "should be no more perplexed at a patient's bedside than empirical physicians. They will make use of all the therapeutic means advised by empiricism; only, instead of using them according to authority and with a confidence akin to superstititon, they will administer them with that philosophic doubt which is appropriate to true experimenters." And this attitude, I venture to think, is the one which is almost universal to-day.

Charles Arthur Lovatt Evans

(To be concluded)

GEOLOGICAL AND ARCHEOLOGICAL RECORDS OF THE YUCATAN PENINSULA

Careful work during the past two decades upon the part of such men as Blum, Gann, Spinden, Morley, Gregory Mason and others, within the region comprising the old homeland of the Maya race, from northern Guatemala (Peten), British Honduras, Campeche, Yucatan and Quintana Roo, has established a few broad facts upon which all are agreed. These may be summarized as follows:

(1) The origin of the Mayan race and its culture somewhere south of Peten in Guatemala, at some indefinite time preceding the Christian era.

(2) The gradual migration of temple cities and cultural centers progressively northward, during the fourth and fifth centuries of the Christian era and the abandonment of previously occupied capitals to the south until a last stand was made at Chichen Itza and Mayapan near the northerly tip of the Peninsula.

(3) The weakening of the race during the latter part of this migration until during the time of the occupancy of the two northern capitals at Chichen Itza and Mayapan, the territory was conquered by the Toltecs from the north, and the Maya race became a dependency of the Mexican, somewhere during the twelfth century A. D.

(4) During the Toltec domination, not long before the coming of the Spaniards in the sixteenth century, the remnants of the Maya peoples were still further decimated by the ravages of disease, leaving but a comparatively few spiritless people to resist the Spaniards, with relatively little memory of their ancient culture, with temples and cities abandoned to the jungle.

(5) During the past two centuries has occurred still further decrease in the population of the aboriginal race in Yucatan, by yellow fever, dysentery, malaria and diseases brought by the white race. Recently the influenza epidemic has killed thousands.

Wide areas of forested lands to-day cover territory once supporting an agricultural population numbering millions, where to-day a few hundreds of chicle gatherers eke out a meager existence during the season of sap flow. The question as to the reason for this progressive northward migration, and later the virtual disappearance of the Maya race, is one which has bothered all investigators. That the two phases of Mayan history may have been related by a common cause has suggested itself. Foreign wars on a national scale there were none, except what incidental fighting occurred toward the end, when the Toltec political ascendancy took place. Contacts with outside peoples, with the bringing of strange plagues to a race with little immunity, could have been very slight. The infiltration of foreigners along the narrow neck of Central America and incidental canoe-borne traffic could have offered few opportunities for the breaking out of epidemics carried by outsiders, who were few and of essentially the same habits of life as the Mayas. The great progressive migration took place during the flowering of the Mayan culture of the First Empire, when they were at the height of their strength and population.

Morley suggests that the land was cleared and corn (maize), upon which the race was dependent for food, planted. Then after a few plantings the heavy grass choked out the corn, and this necessitated the clearing of fresh lands. This hypothesis can not be accepted by any one familiar with the Indian method of planting corn in the tropics. In new land, the underbrush is frequently cleared, the corn sown and the forest felled over the sowing. The first crop sends its stalks up through the felled timber and brush, sometimes to a height of twenty feet. Meanwhile the timber is rotting and collapsing, so that each new crop of corn encounters less difficulty in reaching the air and sun and is better bearing. There is no grass that the writer has ever seen which would retard Indian corn. The comparative ease of clearing enough grass for a hill of corn as compared with clearing new timber