retrogression was manifested, the Girose glacier having retreated six metres since 1919, the Meije nine metres on one tongue of its snout and thirty on the other, the Rateau by two metres, and the Tabuchet by twelve and twenty-five metres on its two fronts.

In reality, however, this retrogression was but temporary, caused mainly by the rarity of snow in the winter of 1920-21 and the relative dryness of 1921. For when the summer of 1922 came round the glaciers had all again clearly advanced, or had at least formed a front of clear blue ice as if the minimum were passed and advance were looming ahead again. That this view was correct has since been clearly proved by the measurements made during the summers of 1923 and 1924. In 1923, for example, the Grandes Rousses glaciers showed unmistakable frontal advances since their last measurement; for example, the glaciers des Rousses and des Quirliés had each elongated by three metres, and the Saint Sorlin by fourteen metres. In 1924 the glacier du Mont-de-Lans exhibited an advance of sixteen metres since 1921, the glacier du Lac ten metres, the glacier de la Meije seven metres, the glacier du Tabuchet thirteen metres, and

the glacier de l'Homme five metres. The positions of 1919 have thus not only been recovered but also passed, and the fronts were all of clear, beautifully clean ice, while a considerable increase of superficial rapidity of movement was also observed, a sure sign of advance.

Hence it seems certain that we are now really in a period of true advance of the glaciers of the Dauphiné Alps, a result in line with that derived from the Mont Blanc glaciological survey. The work on these Dauphiné glaciers has been much more arduous, however, as the writer can testify from having actually seen some of the observers at work. On one occasion a number of them were lost for five hours in a terrific snow blizzard on one of the Meije glaciers, and only reached the refuge hut when frost-bitten and on the point of exhaustion. Such accurate work as is recorded in this report, carried out under such conditions, will be appreciated by all who read it, and most of all by those who know the ground, and the danger and tragic history of this group of mountains, the terrible Meije and its sister peaks, the last of the great Alpine peaks to be trodden by the foot of man.

A. E. H. TUTTON.

The Development of Human Physiology.¹

By Dr. C. G. DOUGLAS, C.M.G., F.R.S.

IN physiology our task is to study the nature of the phenomena which characterise normal life, as shown in the individual organism. At the outset it would perhaps seem presumption on our part to turn our attention to what we must admit to be the most complicated and highly-developed organism, namely, man, before we have been able to elucidate at least the main features of the life-process of more lowly forms; should we not do better to argue from the simple to the complex?

In the last fifty years we have seen the wide extension of what I may term the analytical method of physiological investigation, the attempt to differentiate the various components in the complex system which we call life, and to study in detail each of these components in turn and to render clear the phenomena peculiar to each. The organism is in this method treated as a series of systems—we speak, for example, of the nervous system, the circulatory, the respiratory, and the excretory systems—which, though no doubt but parts of a whole, are yet capable of being treated within limits as independent. In pursuing this method we have a perfectly definite aim, for we are trying to establish elementary facts about the different parts of the body without some knowledge of which we feel, and feel rightly, that a general conception of the whole is impossible. No one can deny that we have acquired in this way a mass of information which is essential to the whole study of physiology, nor is there any reason to suppose that the future will witness any diminution either in number or importance of the contributions thus made to knowledge.

The bulk of this information has been attained by the deliberate and careful investigation of animals by experimental methods, and as I am going to plead the cause of human physiology, may I say at once, lest any one should misconceive my purpose, that I do not believe that progress in physiology and in medical science to the lasting benefit of mankind is possible without employing such methods. But, while acknowledging the great debt which we already owe to these investigations, and my firm conviction that their further prosecution will be fully justified in the future, I have to face the question whether the method has not in reality some limitations.

We are bound, I think, to admit frankly that direct observation by methods involving operative procedure on the anæsthetised animal cannot by itself give us the full answer that we require. I have defined physiology as the study of the nature of the phenomena which characterise normal life, and normal life involves constantly varying activity of all the different organs of the body. Under the influence of an anæsthetic our subject is no longer normal, and we have perforce deliberately to close our eyes to that fundamental aspect of life—ceaselessly varying natural activity. We are forced to adopt methods of investigation which are essentially highly artificial; the stimuli which we employ are usually coarse, and the changes to which we subject the organs gross, compared with the delicate alterations to which these same organs respond in natural life.

If we are to understand life we must ultimately adopt methods of investigation which do not interfere with the normality of the organism or its power of self-maintenance; and clearly, so long as

¹ From the presidential address delivered to Section I (Physiology) of the British Association at Leeds on Sept. 2.

we keep this aim before us, we are perfectly justified in making our observations on any animal the study of which we think will help to solve our problem. The conditions will be satisfied so long as our experimental treatment, whether that involves operative procedure or not, does not materially prejudice the delicate regulation of bodily functions which is so evident in the normal intact animal. The point which I want to emphasise is that, in the study of normal physiology, man is in many instances a far more advantageous subject for investigation than are the lower animals.

It may be urged that, so far as concerns the natural variations in activity of everyday life, we may study the lower animals just as profitably as man. But can we guarantee that any animal, even though highly trained, will provide the particular state of activity that we may require at the moment? Man at least will conform with our requirements, and will maintain at request either rest or any degree or type of activity which we may desire. What is more, he, though himself the subject of investigation, can help us to make our observations, and very often intelligent co-operation on the part of the subject may render easy experimental procedure which would otherwise be impossible. We gain, too, the advantage of learning the subjective impressions of the person on whom we are making our experiments.

A review of the advances made in recent years in our knowledge of the general metabolism and energy exchange, of the regulation of the respiration and circulation, of the function of the kidneys, digestive organs, and nervous system, and of the general adaptation of the body to alteration of environment justifies the assertion of the advantage derived from studying the human subject; for experiments on man have already thrown much light on the actual quantitative changes in organ activity during normal life, on the close functional linkage of different organs and on the power of adaptation to altered circumstances. Direct experiments on anaesthetised animals, on the other hand, very often afford information about potentialities in the body rather than actualities.

The more we examine the normal behaviour of the body the more is it brought home to us that the maintenance of the natural life and integrity of the organism depends on the closest co-ordination of all its different parts; all the organs are interdependent, and can have no real existence save as active components of a corporate whole. Life consists of a delicate balance of all the different functions, a balance that is being continually adjusted so as to ensure the maintenance of the true functional capacity of the organism in its struggle for self-preservation in a constantly varying environment. As an agent in securing this exquisite co-ordination a physico-chemical change in the blood stream may at one moment be prominent, at another moment a nervous reflex. Very frequently both factors co-operate, the physico-chemical change ensuring perhaps strict quantitative co-ordination of activity, the nervous reflex

offering the advantage of speed and simultaneity of response in parts of the body remote from another. The two factors are not antagonistic: one is not gradually supplanting the other, but each plays its part in its own peculiar sphere.

When we recognise the exactness of the co-ordination of the different functions in normal life, we cannot fail to appreciate the relative crudity of some of the experimental methods we are forced to use in physiology. Methods that interfere with the mutual interdependence of the different organs can only give us a partial insight into the problem of life, and if we use these methods, we must correct the impression that we gain by comparison with the true normal.

When we review the development of physiological thought in the last quarter of a century, we cannot close our eyes to the fact that investigations on man are becoming of increasing importance, and that the contribution made by human physiology does not involve mere matters of detail. There is something of far more importance than that, for the evidence of balanced interaction of the functions of the different organs with the preservation of the functional integrity of the whole, which is so convincingly brought home to us in experiments on the human subject, has made us appreciate that in physiology the organism as such, be it man or one of the lower animals, is our unit, and that, whatever methods we may employ in our investigations, we must keep that essential fact before us. In the problem of what is meant by life we have set ourselves the most complicated puzzle in existence. I firmly believe that human physiology, limited though our knowledge may as yet be, has already given us a vague glimpse of the final picture which we hope to complete, and has put us in a better position to fit together the individual fragments, the tiny components of the puzzle, which we have been accumulating in such profusion in years past.

The truth is that we cannot confine ourselves exclusively to any one method in physiological investigation. Unless we deliberately study the normal organism in its entirety, I do not see how we can gain any adequate conception about what is really implied by life, but once we have begun to gain that conception we can employ the methods of detailed analysis about which I have spoken earlier with hope of real success. There has been a tendency of late to differentiate the subject of bio-chemistry from physiology, but this distinction, though it may have the merit of administrative convenience, can have no real justification if the ultimate aim of the physiologist and bio-chemist is, as I suppose, the same, namely, the investigation of the nature of living processes. Physiology and bio-chemistry in fact merge into one another, and if we call to our aid the resources of chemistry and physics, that need not imply that we are any the less physiologists, but we have to be on our guard that we do not by imperceptible degrees turn from the path of biology into that of pure chemistry and, in so doing, miss the goal that we set out to attain. If an example is needed of the application of

chemical and physical methods of investigation to the normal living organism, I would point to the work that has been done on human physiology, for it seems to me that a just claim may be made that in that there is represented at least one aspect of true chemical physiology.

In our enthusiasm for research we are apt to overlook the fact that unless our teaching can keep pace with our research the general advance of learning must be seriously impeded. I cannot help feeling that our teaching of physiology would be more satisfactory if human physiology occupied a more prominent position. I am not thinking so much in this connexion of advanced teaching, for the number of students who take advanced courses is relatively small and it is fairly easy to arrange suitable work for limited numbers. The great majority of students who take up the study of physiology do so as a preliminary to a medical career, and but few of them in the end pass on to advanced courses, and it is of the elementary teaching of physiology required as a preliminary to the study of clinical medicine, or an antecedent to more advanced honours courses, that I wish to speak.

So far as the theoretical side of physiology is concerned, books enough and to spare are available; and if the student is dissatisfied with his textbook or his teachers he can turn, unless he is appalled at the prospect, to the ever-increasing number of monographs, reviews, and special volumes which offer to him information on almost every conceivable branch, however obscure, of physiology. It is, I think, the practical instruction in physiology with which we may legitimately find fault. We are, I suppose, in part tied by tradition, in part handicapped in our laboratories by the accumulation of apparatus of bygone days, and it is easy to point to lack of funds as an excuse for continuing in the same path as those who preceded us. The fact remains that so far as elementary practical physiology, as distinct from bio-chemistry, is concerned, reliance is still largely placed upon an experimental treatment of some of the rudimentary phenomena exhibited by amphibian muscle and nerve. I do not deny that some of these experiments do afford information which is of value to the student, but I am also prepared to maintain that others are merely artificial, and but relics of the past that would be better omitted, and that they in no way represent the viewpoint of the present day in this branch of physiology. But though experiments on muscle and nerve still figure largely in the physiological curriculum, it is noticeable that simple experiments illustrating the progress of more recent years are gradually being introduced, and that in some laboratories a far more serious attempt has been made to remodel the curriculum than in others, and to afford an opportunity for gaining acquaintance with some of the facts of human physiology.

Such a change in outlook is very welcome. When dealing with a subject which is so rapidly progressive as physiology, I feel that we are bound to reconsider our methods of teaching at intervals,

if we are to render those whom we instruct reasonably conversant with the actual state of knowledge at the time; mere addition to the curriculum is of no use, what is needed is reconstruction. Do not think that I say this in any carping spirit. After all, some facts have become so firmly established in the past as to have become axiomatic, and we must be content to accept many of these without constant repetition of their proof if time is to be found to give the student some indication of the experimental developments which have led to alteration and extension of our earlier conceptions. If practical courses of instruction are to play their full part and not degenerate into simple exercises in skilful manipulation, they must be brought into line with current physiological thought; they must, even though the experiments be simple, help to convince the student of the meaning and truth of what he reads. I am certain myself that a serious attempt to incorporate even in elementary courses experiments on human physiology will be amply justified.

I confess frankly that in my own case if I want to understand the facts of physiology I have to think of what they might mean to me in my own person; I cannot think easily in terms of lower animals. I have got to translate the information before I can use it. I do not believe that I am peculiar in this respect. Many a student would, I am sure, acquire a deeper and more real interest in physiology if his attention was directed to some of the essential facts of human physiology at an early stage in his instruction. Show him something of what really happens in himself in the natural course of his daily life, awaken his curiosity about the way in which these events are actually accomplished, and he will then more readily understand the significance of what he learns from other sources. As it is, he runs the risk of being overwhelmed by the literature of the subject that he is studying and of losing himself in details which he cannot place in the right perspective: he too often fails to see the wood for the trees. The quantitative interdependence of function in the body can be well illustrated by simple experiments in human physiology; and a more convincing introduction to those quantitative conceptions which must form the basis of physiology, as of other branches of natural science, can be gained, I think, in this way than by, say, a few quantitative bio-chemical analyses which, essential though they may be in themselves, can scarcely be more than exercises in method in the early days of a student's career.

These students are for the most part going to follow the profession of medicine, and in the short time available our aim must be to develop their powers of thought and initiative that they may be the better equipped to face the future when they go out into the world; and if they leave us with only the recollection of a medley of seemingly disconnected facts, it is quite intelligible that they may fail to grasp what physiology really means, and that a gulf, for which there can be no justification, will deepen between physiology and medicine. Physiology is not medicine: the physician sees a

side of life which the physiologist does not meet in the cold aloofness of the laboratory. The art of medicine is not based merely on the application of skilled technique; it demands in addition a full and sympathetic comprehension of human nature with all its hopes and fears, its frailty and courage. Yet the more the physiologist can find out about the characteristics of normal life the greater will be his service to medicine, for a knowledge of the normal cannot but help us to estimate with greater certainty the influence of the abnormal, and the underlying principles of adaptation of organ activity which we as physiologists recognise in the functional changes which exhibit themselves in everyday life; and, in the reactions to alterations of environment, have their counterpart in medicine in the natural efforts at compensation for the effects of injury or disease, a compensation which it must be the aim of the physician to encourage and assist.

There is yet another field in which scope may be

found for human physiology. In the growing complexity of the modern world the improvement of the general standard of life is a matter which appeals to all of us. Physiologists have already played a prominent part in investigations into the means by which conditions may be improved and risk reduced in industrial processes, into the factors which affect the efficiency and welfare of the working classes, and into the influence of diet on health. Problems such as these, the solution of which is of direct benefit to the community at large, call for the practical application of physiological principles. We ought not to regard applied physiology as something distinct, as something to be divorced from the more academic study of theoretical physiology; it should be looked upon as the natural extension of our researches in the laboratory. These practical problems in their turn often suggest new lines of inquiry, new methods of approach, by which the science of physiology may be still further advanced.

Obituary.

PROF. R. A. LEHFELDT.

PROF. ROBERT ALFRED LEHFELDT, professor of economics at the University of the Witwatersrand, Johannesburg, whose untimely death is reported from Cape Town, was born at Birmingham on May 7, 1868, and thus was in his sixtieth year. Lehfelddt's initial education and pursuit of science was largely the outcome of strenuous personal endeavour. Obtaining a scholarship at St. John's College, Cambridge (1886), he secured a first class in both parts of the Natural Science Tripos. Meanwhile he read for a London degree, eventually taking his D.Sc. in physics. On leaving Cambridge, Lehfelddt occupied a post as demonstrator in physics at the University of Sheffield (then Firth College); later, he became professor of physics at the East London Technical College, remaining there until appointed (1906) to the chair of physics, Transvaal Technical Institute, Johannesburg, a post resigned on his acceptance (1917) of the professorship of economics in the University of the Witwatersrand.

Among several papers by Lehfelddt published in the *Philosophical Magazine* are: "A Potentiometer for Thermocouple Measurements" (1903), and "The Treatment of Electrodynamics" (1909). He translated from the German, Van't Hoff's lectures on theoretical and physical chemistry (3 vols., 1898-1900), also Nernst's theoretical chemistry (Macmillan, 1904), revised in accordance with the fourth German edition. He was the author of a text-book of physical chemistry (general theory) in the series edited by Sir William Ramsay (1904, a new impression appearing in 1920). Lehfelddt was a valued worker for the Royal Society's "Catalogue of Scientific Papers," series 1884-1900. His services are referred to, along with other coadjutors, in Vol. 13 (1914).

In certain fields of economics Lehfelddt was a persistent advocate. The *Economist* published on Nov. 6, 1926, the first of a series of five articles of his (afterwards appearing in pamphlet form) entitled

"Controlling the Output of Gold." A proposition embraced the setting up of an international commission charged with the duty of buying out and becoming the owner of the gold-bearing and gold-producing ores of the world. Lastly, the *Economist* on Sept. 24, 1927, published suggestions leading to a more economic mode of currency in England.

In early years Lehfelddt was reticent, difficult of approach, and somewhat inclined to moodiness. Unfortunately, it would seem that these general characteristics, so far from diminishing with time, gathered force. Notwithstanding, he accomplished much sound work in science and in cognate subjects, and his old associates at home and those overseas will deeply deplore his premature decease.

PROF. LUDWIG DARMSTÄDTER, director of the State Library, Berlin, died on Oct. 18. A native of Mannheim Darmstädter was educated at the Universities of Heidelberg, Leipzig, Berlin, and Paris. About twenty years ago he presented to the State Library, Berlin, his valuable collection of porcelain and of autographs and other documents relating to men of science. This collection, known as the "Dokumenten-Sammlung Darmstädter," has developed until it is probably the largest of its kind. His best-known work is the "Handbuch zur Geschichte der Technik und Naturwissenschaften."

WE regret to announce the following deaths:

Dr. M. Danneberg, emeritus professor of inorganic chemistry at the Technische Hochschule in Vienna, on Oct. 22, aged sixty-six years.

Dr. R. A. Herman, lecturer in mathematics in the University of Cambridge, on Nov. 29, aged sixty-six years.

Lord Kenyon, K.C.V.O., president of the National Museum of Wales, on Nov. 30, aged sixty-three years.

Prof. Perley F. Walker, dean of the school of engineering of the University of Kansas since 1913, who was known for his work on steam and gas power engineering, on Oct. 17, aged fifty-two years.