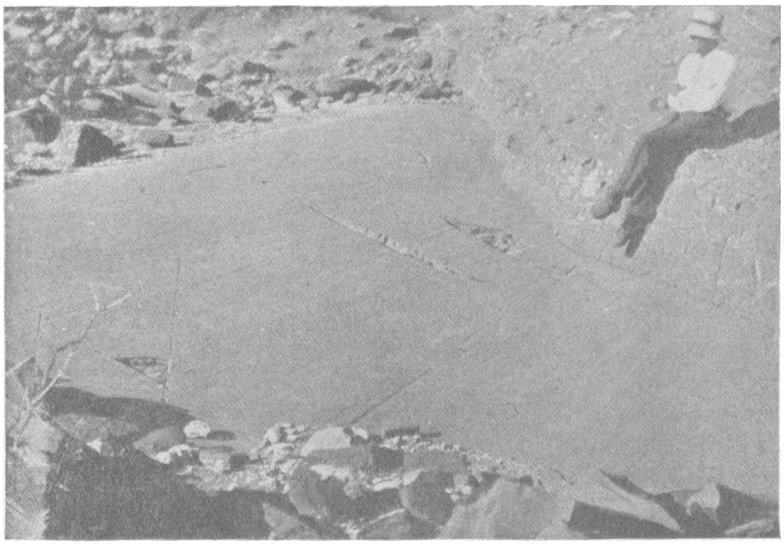
and A. Krämer, on the origin of the Polynesians, and identifies Savaiki (Havaiki, Avaiki, Savaii, &c.) with Java, *i.e.* *savah* (Javanese) = rice-field, and *iki* (also Javanese) diminutive suffix.

GEOLOGICAL RESEARCH IN SOUTH AFRICA.[1]

THE last number of the Transactions of the Geological Society of South Africa cannot fail to attract a greater number of geologists to follow the rapid progress being made in South African geology. This journal once threatened to be the dreariest; it is rapidly becoming one of the most interesting.

The visit of the British Association to South Africa has no doubt directed attention to the many points of interest in the geological history of one of the oldest land masses in the world.

Recent work between the Cape and the Zambezi has shown that the South African rocks present phenomena unparalleled elsewhere. The Dwyka Conglomerate undoubtedly affords the finest study of an ancient Glacial period. With this geologists have become familiar, but no more convincing examples have been found than those of the glaciated surfaces and boulder beds in Griqualand West described and beautifully illustrated by Messrs. Young and Johnson; but the Dwyka is not the oldest glaciation. Evidences of another have been obtained by Mr. Rogers from the Table Mountain Sandstone series, and he now describes a third and much older glaciation towards the summit of the Griquatown series. South Africa is thus yielding information on those points on which the older formations of the northern hemisphere are generally so persistently silent.



This is a very well preserved striated surface of flagstone forming one of a series of such exposures at Blaauwbosch Drift. The striæ run from N.E. to S.W. The grey patches on the glaciated rock, which are only faintly shown in the photograph, are delicate Bushman chippings. The upper rock seen at the top right-hand corner is boulder shale. From "Transactions of the Geological Society of South Africa."

The unfossiliferous and lithologically similar pre-Cape rocks have of late years been proved to be built up of several unconformable groups. The number is added to in the present volume. They also contain rocks of a unique character, none more so than the remarkable Blink Klip breccia of the Griquatown series described by Mr. Rogers. This is a brecciated rock, exceeding 200 feet in thickness, formed by the collapse of the Lower Griquatown series into hollows dissolved out in the underlying limestones and dolomites.

That the interesting character of South African geology is not recognised to the full extent it demands is perhaps due to the overwhelming preference hitherto given to the economic study of the gold-bearing conglomerates and coal deposits. A utilitarian spirit still apparently holds a prominent place among several members of the Johannesburg school of geologists, of which an indication will be found in the present volume. Why, it is asked, is the Transvaal Survey engaged in the investigation of "outside" areas, where "outside" seems to include everything beyond the immediate vicinity of the golden city? Considering the number of ridiculously divergent opinions concerning the age, order of sequence, and stratigraphical relationship of the gold-bearing conglomerates, it is evident that either the problem lies beyond solution or that the secret will be found in the outlying districts. That the enveloping movement around the Central Rand is being rapidly and systematically carried on is shown by the work of the Transvaal surveyors and by that of Mr. Rogers in Griqualand West. The results obtained by both surveys not only justify their existence, but warrant that, in happier times, they will receive a more liberal help. The fuller knowledge so obtained can afterwards be applied to any special economic region with that nicety of attention to detail on which the success of applied geology so much depends.

W. G.

[1] Transactions of the Geological Society of South Africa. Vol. ix., January to April, 1906. Pp. 1-56. (London: Wm. Wesley and Son.) Price 15*s*.

THE SCOPE AND PROBLEMS OF PROTOZOOLOGY.[1]

PROTOZOOLOGY, a science that has only in most recent times attracted general attention, is nothing more or less than the study of a group of organisms which zoologists term protozoa, and therefore, in order to make clear the meaning and scope of the science, it is only necessary to explain, first, what the protozoa are, and, secondly, why one should study them—to the extent, that is to say, of having independent university chairs for that purpose.

In sea-water, or in the waters of lakes, rivers, ponds, and ditches, in any small puddle or in damp earth and moss, in fact, in any situation where sufficient moisture exists to float their tiny bodies, protozoa can almost always be found, usually in abundance. If an infusion or liquid containing organic matter be exposed for a sufficient time to the air, protozoa will make their appearance in it and multiply. And, finally, there remains for mention a large, but very important, section of the protozoa which do not get their living in an honest and independent manner, but live as parasites of other animals and nourish themselves on the internal juices of their hosts, it may be in the digestive tract, or it may be in the blood, or in some other organ or tissue of the body. Thus the situations in which protozoa may be found show the utmost diversity of character. It must not be supposed, however, that every minute living thing which can be detected growing or moving in a moist environment is necessarily one of the protozoa. Here we have to draw some distinctions and to eliminate certain types of organisms. In the first place, the protozoa must on no account be confused with the bacteria, a group of organisms which stands sharply apart from other microscopic forms of life. Apart from the bacteria, the world of microscopic life can be further divided into two groups, the one comprising those of animal nature and habit, the other those more distinctly vegetable in their mode of life. The distinction between plant and animal when applied to these lowly forms of life is, however, a most unnatural and artificial line of cleavage. It is impossible, therefore, to use vegetable or animal characteristics as a criterion for separating these minute organisms into natural groups. For this reason it has been proposed to unite all these primitive forms of life into one group

[1] Abridged from the inaugural lecture delivered before the University of London on November 15 by Prof E. A. Minchin, Professor of Protozoology.

under the name protista, meaning literally the very first things, living things (zoa) being understood. The protista would then rank as a separate *kingdom*, that is to say, as a category equivalent to the animal and vegetable kingdoms respectively.

Theoretically, there can be no doubt that to group all these primitive living things together as protista is the most natural and proper way of dealing with them. We should then talk of protistology rather than protozoology, and of a protist rather than of a protozoon, which would at least be more euphonious. But this method of dealing with these creatures is inconvenient and unsuitable in practice, chiefly because the group protista comprises such a vast array of organisms of different types that no one investigator can deal with them all satisfactorily, or with the different technical methods requisite for their study, and a division of labour has become necessary. Hence the bacteria have been assigned to the domain of a special science, bacteriology; the botanists claim for their sphere of investigations all those protista which are of vegetable nature; and there remain, finally, for the zoologist, those protista which can be regarded as *animals*, and which are, therefore, termed the *protozoa*.

We have now got so far, that the protozoa are minute, microscopic forms of animal life. There are, however, many minute animalcules which are by no means to be considered as protozoa. If we compare the protista with higher animals and plants, we find at once a fundamental difference. In the body of a protist the living substance, the protoplasm, is not divided up into cells, but forms one simple mass; that is to say, the whole body of a protist is comparable to a single one of the cells that build up, in vast numbers, the complex body of a higher animal or plant. Expressed briefly in the technical jargon, we may say that a protist is a unicellular organism, and that a protozoon is a protist of animal nature. Since such organisms may be regarded as the most primitive types of animal life, the earliest, probably, to appear upon our globe, they have been named the protozoa, or "first animals."

We are now in a position to attack the second question that was suggested for consideration, namely, what is the interest and importance specially attaching to the study of the protozoa? This is a matter which can be considered most conveniently from two different points of view, the theoretical and the practical. In dividing my discourse into these two heads, however, I do not wish to be understood to imply that there is any real distinction between theoretical and practical science. The whole history of human progress and culture shows that what is theoretical to-day is practical to-morrow. This is such a commonplace that it would be superfluous to waste time by citing instances. The theoretical knowledge of scientific principles must necessarily precede their application; hence to discover these principles is, even from the practical point of view, the most important occupation of the human intellect. This is a point of view which cannot be too strongly emphasised, and to which I shall return again.

From the theoretical point of view the protozoa are of the greatest interest on account of their primitive nature, and the light which they consequently throw on many obscure vital processes. The cells which compose the tissues of higher animals have become extremely specialised for their particular functions and modes of life, and their structural or developmental characters tend to follow certain stereotyped patterns and to conform to uniform rules of procedure, due perhaps to a common origin and ancestry. In the protozoa, on the other hand, each individual is an unspecialised cell, capable of performing equally well all the functions of life as a free and independent living organism, and the structural features or developmental processes of protozoa exhibit the utmost possible diversity of character. Only by the detailed comparative study of this primitive diversity is it possible to discover the course of evolution which has culminated in the relatively uniform characters of cell-structure and cell-behaviour in the higher forms, and so to elucidate the true significance of many obscure cytological problems. Just as the higher division of the animal kingdom may be reasonably supposed to have originated from protozoan ancestors, so the cytology of the higher animals may be said to have its roots in the cytology of the protozoa, and the same is perhaps true also of other subdivisions of biological science.

Turning now to the practical aspects and applications of protozoology, we find that these arise from the peculiarity already mentioned of many of these organisms, namely, that they live as parasites of other animals, and may produce diseases in them. For this reason the investigation of the protozoa has, like that of the bacteria, become of immense importance to medical and veterinary science, and for this reason protozoology has taken shape as a definite science, and has gained recognition, outside zoological circles, just as bacteriology did before it. Formerly it was always bacteria that were sought for as the agents of diseases. Now it is known that many diseases are caused by protozoa, and not by bacteria, and it is suspected that this is the case also in certain diseases of which the cause is still obscure.

Although, as I have stated, the practical importance of the study of protozoa has only been recognised generally in the last few years, nevertheless the actual discoveries of important disease-producing protozoan parasites date back, in some cases, a quarter of a century. Prof. Koch, of Berlin, has directed attention to three great discoveries, each of which opened up the way for a new line of investigation, and was of the utmost importance in establishing the true cause of diseases previously mysterious in nature. The first was the discovery of the malarial parasites by Laveran in 1880. The second was the discovery of the parasites of the so-called Texas fever of cattle in America by Smith and Kilborne in 1893. The third was the discovery of the parasites of tsetse-fly disease in Africa by Bruce in 1895.

The malarial parasite was first observed by Laveran, then an army surgeon, in the blood of fever patients in the military hospital at Constantine, in Algiers. Though working with inferior microscopical apparatus, Laveran described clearly all the principal stages that can be made out in human blood. This sensational discovery was received everywhere with coolness and disbelief. At that time the cause of malaria was generally believed to be a bacterium, which was named *Bacillus malariae*, and it was some years before the bacillus was discredited, and Laveran's parasite established, as the true cause of the disease. It still remained a mystery, however, in what way this minute organism got into the human blood, and the view was put forward that it gave rise to minute germs which passed out of the body and were scattered abroad, and which, like many other germs of protozoa, were able to float in the air. It was supposed that those germs were then inhaled by healthy persons, and so gave rise to the disease. This was simply an extension of the old miasma theory, the notion that the disease was contracted by inhaling the air of swamps and marshes, a notion expressed in the word malaria, meaning literally bad air. It remained for a countryman of ours, Major Ronald Ross, to discover, by a series of brilliant experiments and observations, the part played by mosquitoes in disseminating the disease. It was found, however, that a remarkable relation existed between the species of mosquitoes and the species of malarial parasites. The common gnats, for instance, belonging to the genus Culex, are incapable of transmitting the malarial parasites of man, but convey those of birds from one bird to another. The mosquitoes which carry the malarial parasites of man belong to a different genus, Anopheles, and they in their turn are incapable of transmitting the malarial parasites of birds. This is one of those remarkable adaptive specialisations so often seen in nature.

Let us now follow the course of infection briefly. If a mosquito bite a man suffering from malaria, it takes in a drop of blood in which are contained various stages of the malarial parasite. The blood is, of course, digested slowly in the mosquito's stomach, and if the mosquito be a Culex, all stages of the parasite are digested also but if the mosquito be an Anopheles, certain stages of the parasite resist digestion. In the parasite of pernicious or tropical malaria, the resistent stages have a form like a sausage, and are known commonly as crescents. These crescents undergo changes in the mosquito's stomach which give rise to sexual forms, minute, slender males, and relatively large, bulky females. Fertilisation takes place, and the result is a slender, worm-like creature which progresses by gliding movements, and which penetrates into the wall of the mosquito's stomach, and there multiplies to form an immense number of very minute germs, producing a small tumour on the outer side of the wall of the stomach. After a time this tumour bursts, and the little germs pass into the blood of the mosquito. They are carried to and fro in the mosquito's blood circulation, but ultimately pass into its salivary glands, and the mosquito is now infectious. When it next feeds, a swarm of the malarial germs passes down its proboscis into the puncture it makes, and in this way the disease is passed on from one person to another.

The second important discovery mentioned above, that of Smith and Kilborne, concerns a fatal epidemic disease of cattle and other animals, sometimes termed red-water. In this case the two American investigators discovered, not only the cause of the disease, but the method of transmission. The parasites are tiny, pear-shaped bodies which penetrate the blood corpuscles and multiply there, so that two or more parasites may be found in one corpuscle. Similar parasites are now known to occur in sheep, horses, dogs, monkeys, and rats, but are not known with certainty to occur in human beings.

Smith and Kilborne discovered that the parasites of cattle red-water were transmitted by ticks, but not quite in the same way as malaria is transmitted by the mosquito. When a tick feeds on an infected animal, it does not itself become infectious, but gives rise to offspring which are capable of infecting healthy animals, so that the parasite passes through two generations of ticks. Unfortunately, nothing intelligible is known of the development of the parasite within the tick, and an important field of investigation is as yet untrodden.

[For an account of the third discovery referred to above, that of Bruce, see NATURE, November 15 (p. 56).]

Enough has been said, I think, to show that protozoology offers a most interesting and important field of investigation, of which as yet only the fringe has been touched. Almost every day brings news of some new discovery in this field. There are still, however, many questions to be answered relating both to protozoa and to the diseases caused by them, especially in the tropics, where insect life of all kinds is so developed, and there are so many different blood-sucking insects to carry infections of all kinds.

This brings me now to the concluding section of my discourse—what are the problems of protozoology and how should they be attacked? The problems that present themselves to the student of the protozoa are principally of two kinds. In the first place, there are purely zoological problems, such as the recognition, classification, and registration of the innumerable varieties and forms of these tiny creatures; the tracing out of their complicated life-histories and their bewildering changes of form and appearance during development; and the study of their vital processes and reactions to surroundings, as throwing light on many problems of cytology, heredity and evolution, of psychology and physiology. In the second place, the results obtained by the zoologist—that is to say, by anyone working according to zoological methods—must be applied to the elucidation of questions relating to disease in man and beast, in other words, to the requirements of the healing art, as practised by the medical man and the veterinary surgeon. Here, however, all the zoologist can do is to supply a knowledge of facts and principles of which the healer can make use, and the final beneficial result must be obtained by a collaboration of the investigator and the practitioner.

Although it may be urged with justice that the most important outcome of human science is its application to human needs, it would be the greatest possible mistake to attempt to confine any scientific study to just those problems which are thought likely to yield results of direct practical importance. Such a course would be short-sighted in the extreme, and would tend to produce a narrow outlook and a limited range of ideas, in the place of broad fundamental principles on which to base deductions for practical guidance. Thus, to apply this statement to the special case of protozoology, the forms most important for medicine are those which are parasitic upon man, but it would be absurd to study only these forms, first, for practical reasons, because it is easier to experiment upon animals than upon our fellow-men, and, secondly, because the study of many different parasites and their development supplies analogies which throw light upon obscure points in the life-history of those attacking man. But if we take a still wider view, we find that three-fourths at least of the protozoa are not parasites at all, but live free, independent lives in various situations.

It is obvious, therefore, that to understand properly the highly-specialised parasitic protozoa we must be acquainted with the more primitive free-living forms first and foremost. This conclusion may be illustrated by a few facts from the career of the late Dr. Fritz Schaudinn, whose recent death at the early age of thirty-five was a most deplorable event, cutting off an investigator who, by his genius and industry, had won the very foremost place in the ranks of protozoologists. The bulk of his work was done on forms not of importance from the practical, that is to say, the medical, point of view, and yet it is not too much to say that his work has modified all our ideas upon the protozoa and has built up the modern conceptions of these creatures, so that no one at the present time can write upon them without taking into consideration the facts and principles discovered by Schaudinn, whose work is a living demonstration of the practical, as well as theoretical, imporance of non-practical scientific study.

The physician and the zoologist work from points of view which, though apparently opposed, are in reality mutually helpful. The physician, of course, takes the side of the patient, and his only object is to extirpate the parasite. The zoologist, on the other hand, identifies himself as an investigator with the interests of the parasite, and tries to become acquainted with all its migrations and changes, studying it for its own sake. In short, the zoologist must deal with protozoa as if he loved them, but the medical man as if he hated them. There can be no such thing as protozoology studied exclusively in relation to medicine. Protozoology must be studied as a science in which all knowledge is helpful, directly or indirectly. When the protozoologist has worked out his life-histories and obtained his results, then the medical man steps in and carries off the honey to the medical hive. In this way, by the cooperation of the purely scientific investigator with the practitioner, we may hope that protozoology may have before it a bright future, in which both theoretical science and the practice of the healing art may be advanced and benefited to an equal degree.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Vice-Chancellor announces that the treasurer of the Cambridge University Association has recently paid to the benefaction fund of the University the sum of 904*l*., resulting from the appeal for the building fund for the new museum of archæology and ethnology. This payment, together with 60*l*. already received by the benefaction fund, is intended to form a nucleus of 1000*l*. for the building fund of the museum. The Vice-Chancellor publishes also a list of subscriptions, paid or promised, amounting altogether to 12,325*l*., toward the building fund of the department of agriculture.

After considering a resolution of the Classical Association in favour of abolishing the Greek grammar paper in the previous examination, the board of examinations proposes that in part i. of the previous examination (*a*) the separate paper at present set on Greek and Latin grammar be discontinued; (*b*) the time allowed for the two papers on the Greek and Latin classics be increased from 2½ hours to 3 hours, in order that more questions in grammar may be set than at present, the questions in grammar to be such as arise from or are suggested by the passages given for translation; (*c*) the papers set on the alternatives to the Greek and Latin classics be similarly lengthened, with the same object; and (*d*) these changes shall first take effect at the examination to be held in October, 1907.

Sir James Dewar, who will be unable to lecture next term, has nominated Mr. H. O. Jones, of Clare College, as deputy for the Jacksonian professor of experimental philosophy during the Lent term of 1907. Mr. Jones has