amount for a period of, say, four years. "From that estimate he divided up the whole of the guano-archipelago into zones. He made certain practical suggestions for the protection of the birds with a view to allowing them to deposit and to have a rigorous close-season, and also a period of rest in each of four years. Only one zone would be worked every year, thus leaving a period for recovery." A remarkable event occurred just before Dr. Forbes's visit, almost the whole of the birds having deserted the islands in November, 1911, and not returning until February or March, 1912, leaving their young to perish from starvation. An unusually severe earthquake shock is considered by Dr. Forbes to have been the probable cause of the exodus, and he surmises that the birds may have betaken themselves northwards to the Galapagos Islands.

The supreme importance of birds to the agriculturist, as being in the main the only effective check on most of the insects by which crops are ravaged, is perhaps more fully and more generally recognised in the United States than in this country. Evidence of popular interest in this matter among our American cousins is afforded by the first article in the June number of *The National Geographic Magazine*, which is a reprint of a "Farmers' Bulletin," issued some years ago by the Agricultural Department, containing an account of fifty species of birds commonly frequenting American farms and orchards. In its new guise the article contains a coloured illustration, printed in the text, of each of these fifty species. Although small, the figures are beautifully executed, and form a striking instance of journalistic achievement.

In an illustrated article on national bird-reservations in the United States, published in the May number of *The American Museum Journal*, Prof. T. S. Palmer points out that, in addition to protected breeding places, refuges have been established in the west for birds while on passage. A reservation of this type "comprises merely a narrow strip of land bordering the reservoir, and is set aside to afford the birds a resting place on their journeys north and south. Some of these reservations were created before construction work was completed and before there was any water to attract the birds, in order to afford protection as soon as the reservoirs were filled and the birds began to visit them."

In an article on the velocities of migratory birds in the July number of *The Zoologist* Mr. F. J. Stubbs disputes the belief that migrants prefer to fly in the teeth of the wind, and likewise that they do so in order to escape the inconvenience of the wind ruffling their plumage by blowing obliquely through it from behind. The fact that head-winds undoubtedly bring most migrants has been a main argument in support of the former belief, but it is urged that such winds stop migration, and that birds flying under these conditions are really retarded. The "feather-ruffling" theory, on the other hand, is stated to be based on a misinterpretation of the fact that such birds as lapwings constantly stand head-to-wind in rough weather, and that if they happen to turn ruffling of their feathers ensues. For the author's arguments in support of his views, our readers must be referred to the article itself.

In an account of a recent visit to Phillip Island, published in *The Victorian Naturalist* for June, Mr. J. Gabriel states that sixty species of birds were identified, of which sixteen are sea or shore species, leaving forty-four as residents on the island, an excess of eight over a previous record. Protection, it is urged, is sorely needed for the mutton-bird and the little penguin, the numbers of which are rapidly diminishing owing to incessant persecution.

BLOOD-PARASITES.[1]

YOU will remember that Mephistopheles, when he insists upon the bond with Faust being signed with blood, says, "Blut ist ein ganz besondrer Saft" ("Blood is a quite special kind of juice"). Goethe would probably not have used the word "Saft" had he been writing "Faust" to-day instead of in 1808, for at that time the cellular elements of the blood—although they had been seen and described by Leeuwenhoek in 1686—were believed to be optical illusions, even by so distinguished a person as the professor of medicine of that time at the Sorbonne. The incredulity of scientific men as to what they see is proverbial and astounding, fortunately; but it is probably because science is really quite sure of nothing that it is always advancing.

I have the privilege this evening of trying to show you the barest outlines of our present knowledge of the parasitology of the blood. It is a subject of great practical and economic importance, as many grave diseases of man and beast are caused by these parasites, which, on account of their minuteness, enormous numbers, and very complex life-histories, are very difficult to eradicate or to deal with practically. On this account there is a good deal of the enthusiasm of the market-place mixed up with this subject, which, although a new one, has advanced with great rapidity, and has revolutionised pathology, and medicine so far as possible. From our point of view it began in 1880 with the discovery by Laveran, in the military hospital of Constantine, of the parasite which causes malaria. This caused the protozoa, to which order most of these parasites belong, to oust bacteria from the proud position they then occupied of being the cause of all the ills we have to bear, and to reign in their stead; not an altogether desirable change; for when you have seen what I shall show you, you will agree with me that sufficient unto life is the evil thereof. It has had all the disadvantages of a new subject, and since that time floods of work have been poured into journals, annals, proceedings, &c., some of it of the best, with much of it that is indifferent, temporary, and bad; so that at times it seems as if this branch of science were in danger of being smothered in the dust of its own workshop, or drowned in the waters of its own activity. We do not, nowadays, keep our ideas and scraps of work to ourselves until they are either established, or, as is more likely, dissipated, so we have a huge mass of what is called "literature," filled with many trivial, fragmentary, and doubtful generalisations, many of which we have with pain and trouble to sweep into the dust-bin: nature's blessed mortmain law taking too long to act. You remember Carlyle complained—to use a mild term—of Poggendorff's *Annalen*, and I feel sure that, if he had had to study blood-parasites now, he would have said that it was a much over be-Poggendorffed subject. Blood-parasites are afflicted, too, with terrible names, and with large numbers of them; some have as many as ten or even fifteen different names, perhaps on the Socratic principle, that naming saves so much thinking. And they are in Latin, too, so that the terminology of this subject is a perfect museum of long Latin and hybrid-Latin names. The terminology generally of our later biology is, as one has said, "the Scylla's cave which men of science are preparing for themselves, to be able to pounce out upon us from it, and into which we cannot enter." This will be my excuse if I should use words you do not understand.

I will just remind you of the structure of the blood, that it consists of an extraordinarily complex fluid—

[1] Abstract of a discourse delivered at the Royal Institution on Friday, May 2, by Mr. H. G. Plimmer, F.R.S.

the plasma—which holds in suspension living cellular bodies, called cells or corpuscles. These are of two kinds, red and white corpuscles. The red are by far the more numerous, and in man there are about 5,000,000 of them to a cubic millimetre of blood, but this number varies enormously under the influence of parasites. To these red corpuscles is due the red colour of the blood, and they are the carriers of oxygen, acquired by the aëration of the blood in the lungs, to the tissues. We breathe in order that they may breathe, for we only care about oxygen in so far as they care about it.

The other kind of corpuscles are the white, or leucocytes, and of these in health there are about 7500 per cubic millimetre. A few years ago it was enough to know that there were red and white corpuscles, but now we have to know more. Through the work of Ehrlich we know that there are at least five different kinds of leucocytes in normal blood, which I will just indicate to you.

(1) Lymphocytes.—These are the smallest cells, and contain a relatively very large nucleus.

(2) Large Mononuclears.—These are large, and are called macrophages, as they possess the power of being able to absorb and digest parasites and other foreign bodies.

(3) Polynuclears.—These are characterised by the irregular, moniliform aspect of their nucleus, and they are called microphages for the same reason that the large mononuclears are called macrophages. Both of these are also called generally, phagocytes, on account of their power of ingesting and digesting foreign bodies.

(4) Eosinophiles.—These are characterised by a bilobed nucleus, and by granulations which colour deeply with eosin and other acid colours.

(5) Labrocytes or Mastzellen.—These are rare, and are characterised by large granulations which stain with basic colours.

In parasitic diseases these corpuscles are profoundly modified and altered, numerically and morphologically, and other new elements may make their appearance in the blood.

The blood is essentially the same in all animals, but it varies within certain limits. For instance, the red corpuscles are not of the same size and shape in every animal, and in birds and fishes they are nucleated; in us they are only nucleated in fœtal life and in disease. The mononuclear and polynuclear leucocytes are really separate organisms living in us, and they have qualities which it is very difficult to call anything else but consciousness; so that it is a subtle distinction to draw the line between the parasites—which these leucocytes are, in a way—which are part of us, and those that are not. When the balance of power is well preserved amongst our leucocytes, when they are working well together, then all is well with us; if we are ill, it is because they are quarrelling with themselves or with an invader, and we send for Sir Almroth Wright to pacify or chastise them with his vaccines.

So that, as Darwin said: "An organic being is a microcosm, a little universe, formed of a host of self-propagating organisms, inconceivably minute and numerous as the stars in heaven"—as we ourselves are but parts of life at large.

The three main functions of the blood are: that it is a means of respiration, a means of nutrition, and a defence against invading organisms.

And now to these latter. A blood-parasite proper is a living being, vegetable or animal, passing part or the whole of its existence in the blood of another living being, upon which it lives, this being obligatory and necessary to its life-cycle.

It was in 1841 that the first blood-parasite was seen by Valentin in the blood of a fish, and two years later Gruby gave the name trypanosoma to an organism he found in the blood of a frog. But since Laveran's discovery of the malarial parasite in 1880, we have learnt to differentiate many other parasites as causal agents of such diseases as I shall mention later in connection with the various parasites. But we know as yet dangerously little about most of them, so that we have strenuously to resist the temptation to make our account of them sound too harmonious, before we have found half the notes of the chord we are trying to play. We speak, as it were, with authorised uncertainty, and there are parts of our science which, after all, are only expressions for our ignorance of our own ignorance. These parasites have a very complicated life-history; part of their life-cycle is passed in the blood of man or beast, and part in various parts of the body of some blood-sucking invertebrate, such as a fly, mosquito, or tick, which transfers the parasite to another animal whilst feeding from him. It was thought formerly that blood-parasites would be a restricted order, but the work of recent years has shown that they have an enormous distribution both geographically and as regards their hosts. For instance, during the last five years I have had the opportunity of examining all the animals (in the large sense of the word) which have died in the Zoological Gardens. I have examined the blood of more than 8000 animals, coming from all parts of the world, and I have found parasites in the blood of 587 of them, that is in about 7 per cent., and in 295 species of animals I have found them for the first time. I mention this just to give you some numerical idea of their occurrence and distribution.

It will be better to take first those parasites which live in the plasma, and then those that live in the corpuscles, rather than to attempt to take them in their, at present rather uncertain, biological order; and I will begin at the bottom, biologically speaking, that is with the bacteria which are plants. These only require mention, since they do not live in the blood as parasites proper, but only as accidental parasites—that is, parasitism is not necessary to their life-cycle; they get into the blood in the later, or in certain, stages of certain diseases.

An example is the blood of a Senegal turtle-dove which died in twenty-six hours from fowl cholera. This bacillus was discovered by Pasteur, and is interesting, as it was his work upon it which led to his discovery of the attentuation of a virus, and of its transformation thereby into a protective vaccine.

The first parasites proper I shall mention are the Spirochetes. These have at present rather an insecure position in our idea of nature; they were formerly classed close to the bacteria, but now they are placed tentatively among animals, and they are not yet quite sure of their place. But they, nevertheless, although insecure of their place in the books, produce grave diseases, such as relapsing fever, tick fever of man, the spirochetoses of horses, oxen, and birds, syphilis, and yaws. They, with the exception of the last two, are carried by, and developed in, ticks and bugs; and in tick fever the parasite is also found in the nymph form of the tick, and this is one of the rare instances of heredity of a parasite.

The spirochete of relapsing fever in man was discovered by Obermeier in 1868, and he died from inoculating himself with the blood of a patient with the disease. He was one of the first scientific martyrs; he established our knowledge of the cause of this disease at the expense of his own life.

We will now take a long jump to the Filariæ. These are nematode worms, the embryo forms of which live in the blood; the parent forms, being too large to get through the capillaries, live in many other parts of the body. The larval form lives in the body of some invertebrate—in a few known cases in a mosquito, or in a crustacean. The microfilariæ were discovered by Demarquay in 1863. Many of them show a remarkable periodicity, some appearing in the blood at an exact hour at night, and some in the day, for which phenomenon there is at present no satisfactory explanation.

Some are short, and some long, and some are encapsuled, others not. Filariæ cause various diseases, probably elephantiasis, and certainly enormous varicosities of the lymphatics, chyluria, chylous dropsy, Calabar swelling, and certain tumours.

We now come to the trypanosomes. They are flagellated organisms, which are the cause of many deadly diseases in men and animals, such as sleeping sickness, nagana (or tsetse-fly disease), surra, mal-de-caderas, dourine, and others. They are transferred from animal to animal by biting flies, fleas, lice, and leeches, in which the sexual part of their life-cycle takes place. The first one was seen in the blood of a frog by Gluge in 1842.

A type example is *T. lewisi* in the blood of a rat. This was discovered by Lewis in 1878, and is found in about 25–29 per cent. of wild rats. Some die, but most recover and become immune; it is a very specific parasite, and cannot be transferred to any other kind of animal.

The *T. brucei*, causing nagana or tsetse-fly disease, probably exists in the wild game of South Africa, much as the *T. lewisi* does in the wild rats, but when it is carried by the tsetse-fly to domesticated animals it kills them one and all in enormous numbers.

The *T. gambiense*, which causes sleeping sickness, was first seen by Dutton in 1902, and is carried by another species of tsetse-fly.

Nature attempts to fight against these invaders by phagocytosis. The parasites, however, multiply so rapidly that this method of attack is not very effectual; it can only be so in very early infections, and probably it then often is, that is, before the parasite has had time to start dividing. At the present time the question of trypanosomosis amongst man and animals is, for many countries which have colonies, of the greatest economic importance, so that a great deal of work has been done in the attempt to find a cure. A great many drugs, new and old, have been tried, and some good has been done. The first drug which was found to be of service was arsenic, first in simple and then in complex combination, and the subcommittee of the Royal Society, formed for the purpose of supervising experiments in this direction, suggested the trial of antimony in these diseases, on account of its near chemical relationship to arsenic.

This has given better results than arsenic, and a commission is at present at work in Africa, in the Lado district, trying its effects on a large scale. We found that the salts of antimony were too rapidly eliminated from the body to be successful in the larger animals and man, and so we devised a very finely divided form of the metal itself which we put directly into the circulation, and this has given, so far, the best results. The leucocytes eat it up and transform it slowly into some soluble form, taking, in a horse, for instance, four days to dispose of one dose, and the effect of this is much more profound and lasting than that of the salts. But some trypanosomes always escape, since one dose is never sufficient for cure. In rats with nagana, in which the trypanosomes by the fifth and sixth day may number 3,000,000 per cubic millimetre of blood, the minimum number of doses for cure has been found to be four, and with this dosage it is possible to cure 100 per cent. of rats. So there is still some hope.

It is interesting in this connection to remember what Bacon, whose death, you know, was due to an experiment he undertook to prove the preservative action of intense cold upon animal bodies, says, "Laying aside therefore all fantastic notions concerning them, I fully believe, that if something could be infused in very small portions into the whole substance of blood . . . it would stop not only all putrefaction, but arefaction likewise, and be very effectual in prolonging life." His vision was prophetic!

The bird trypanosomes are very much larger than the mammalian variety, are very dense, and move much more slowly.

An example of an organism very closely allied to the trypanosomes which is found only in fishes' blood is the trypanoplasma. It has two flagella, and the micronucleus is very large. This organism is probably transferred by leeches, but very little is yet known of it.

There are other flagellated organisms which may appear in the blood and live there as accidental parasites. There is a kind of inflammation of the intestines in reptiles (in the large sense) which causes the mucosa of the intestine to become permeable, so that some of the organisms which live in the intestine are able to get into the blood and live there. The only mention of these organisms in the blood is by Danilewsky, who in 1889 found hexamitus in the blood of a frog and tortoise. When in the blood they appear to excite a general œdema and ascites. I have found them now in nine cases. These are interesting as showing the power of adaptation to new surroundings possessed by these parasites.

I now come to the intracellular parasites.

Schaudinn thought that the bird trypanosomes had an intracellular stage, and if this were so they would form a bridge between the extra-cellular parasites, of which I have shown you types, and the intracellular parasites we are about to consider. But Schaudinn seemed, with his very brilliant attainments, to want a little more ballast of medical earth-knowledge. His work on this point has not been confirmed, and he was probably misled by a double, or even treble infection, so that we must think of these intracellular parasites as quite distinct from the others.

I will take first the *Plasmodium praecox*, the cause of the malaria in birds, as this parasite is of great historical interest; for it was Ross's work on this organism and his discovery of the rest of its life-cycle in the mosquito, which enabled him—on account of the great likeness between this and the parasite causing human malaria—to deduce from the one the etiology of the other, which was confirmed by Grassi and others. The *Plasmodium praecox* is, in many stages, so like human malaria that it can only be differentiated by the presence of the oval nucleus of the bird's red corpuscles. The life-cycle is very complex, part taking place in the blood of the bird, and another part (sexual reproduction) in the body of a mosquito. This parasite was first seen by Grassi in 1890; it is very widely distributed, and is very deadly to birds.

Human malaria has been known for centuries. Varro, who knew a good deal about what we should now call hygiene, more than a century B.C., thought that malarial fevers were due to invisible animals, which entered the body with the air in breathing, and Vitruvius, Columellus, and Paladius were of the same opinion. Now we know that the mosquito is again the carrier, and that the sexual part of the parasite's cycle takes place in it, but whether the mosquito alone can account for all the phenomena of malaria is not yet quite certain.

There are three varieties of malaria in man—the tertian, quartan, and quotidian; in the tertian the cycle of the parasite in the body takes forty-eight hours, and in quartan seventy-two hours, and in pernicious malaria the fever is very irregular, but continuous. Whether there are three different parasites, or only one, which is altered according to its environment of host, climate, &c., is still apparently uncertain. Laveran and Metchnikoff believe in the specific unity of the parasite, whereas some observers want as many as five different species.

Just as in human malaria the pernicious form is distinguished by the elongated form of its gametes, so in birds there is a parasite which is distinguished, in the same way, from *Plasmodium praecox* by its very elongated gametes. This parasite is called *Haemoproteus danilewski*. Its development is unknown; it begins as a tiny, irregular body in the red corpuscles of the bird, then it grows in the long axis of the cell and turns round the end of the nucleus. It is possible in these parasites to follow the process of impregnation, which normally takes place in some insect. By taking the blood when full of the long, fully-grown gametocytes, and keeping it for a time outside the body, this process can be followed.

First of all, the gametocytes escape from the blood-corpuscles and roll themselves up into a ball. Some of these remain quiet—the females, curiously, the macrogametocytes—whilst in the microgametocytes active movements are seen; then tailed processes are seen projecting from its surface, which at last get free and wander about in the blood, this constituting the origin of the microgametes from the microgametocyte. They then find a macrogamete, and penetrate into it and fertilise it. This fertilised macrogamete then alters its shape and becomes an oökinete, with the remains attached containing the pigment. It may enter a red corpuscle, but it usually breaks up, because it finds it is not in the stomach of the insect it intended to be in, but between two pieces of glass.

From Hæmoproteus it is easy to pass to a rare and undetermined parasite of the blood of birds called a Leucocytozoon. It occurs in the blood in the form of a long, spindle-shaped, unpigmented body. Very little is known of it except that it is found in its sexual forms. The earliest observers of this parasite —Danilewsky and Ziemann—believed the host-cell to be a leucocyte (hence the name), but Laveran has shown that it is a red corpuscle.

We now come to a group of parasites of great practical importance, the Babesias, formerly called Piroplasma, which are the cause of Texas fever or red-water fever, malignant jaundice, East Coast fever, and biliary fever amongst domestic animals. We know, again, little that is certain concerning this group, except that they are unpigmented parasites of the red corpuscles, and are carried by ticks. They are the most destructive to the blood of any we know. In an ox, I have seen the red corpuscles decrease from 8,000,000—the normal—to 56,000 per cubic millimetre in two days.

Another important group, the Leishmania, is still uncertain of its exact position. In the body they occur as small bodies with a nucleus and micronucleus, but when cultivated on artificial media they become flagellated organisms of herpetotomas type. It is not quite certain what insect plays the part of carrier, but the different varieties of this group cause the diseases known as Kala Azar or tropical splenomegaly, Oriental sore, Delhi boil, Biskra boil, &c., and also infantile splenic anæmia.

The last class are the Hæmogregarines. These are parasites of the red corpuscles of reptiles principally, but they have been described in mammals and birds. We only know certain stages of the greater part of them; they are large, sausage-shaped bodies, not pigmented, and they are supposed to be carried by leeches, ticks, lice, and fleas. They generally have a capsule. In some instances the host-cell is enormously enlarged and entirely dehæmoglobinised, but in most cases the host-cell is not enlarged.

I have now taken you over some examples of all the known types of blood-parasites, but, at best, the picture in your minds must be like that of a landscape taken from a railway carriage at full speed; and the result, I fear, only a kind of clarified confusion, but it will be something if I have succeeded in making it transparent at the edges. What must have struck you most is the smallness of our exact knowledge of many of these extraordinary organisms and the gaps that there are even in this. But the incitement to future work lies in this fact, for

"Things won are done, joy's soul lies in the doing."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

AT University College, Reading, Mr. S. B. McLaren, assistant lecturer in mathematics at Birmingham University, has been appointed professor of mathematics, and Mr. R. C. McLean lecturer in botany.

AN article dealing with the number of students at German universities during the session 1912–13 is contributed by Prof. Rudolf Tombo, junior, of Columbia University, to the issue of *Science* for July 18. The total number of matriculated students was 58,844, and, including auditors, the total reached 64,590. Of the matriculated students 3213 were women, of whom 904 attended the University of Berlin. Of the male matriculated students 26,988 were studying philosophy in the various universities. The largest number of matriculated students, namely 9806, was enrolled at Berlin. The Universities of Munich and Leipzig had 6759 and 5351 students respectively, and Bonn 4179. There were sixteen other universities with from one to three thousand matriculated students. The largest enrolment of foreign students was found at Berlin, where there were 1605, while Leipzig, Munich, Halle, Heidelberg, and Königsberg had numbers from 784 in the first to 244 in the last-mentioned case. Altogether there were 5193 matriculated foreigners enrolled at the German universities; of these 4648 were from Europe, 338 from America, 184 from Asia, twenty-two from Africa, and one from Australia. Of the European countries, Russia had the largest number of students, 2840, Austria had 900, Switzerland 340, and Great Britain 145.

THE following announcements relating to the Imperial College of Science and Technology, South Kensington, have reached us:—Mr. Otto Beit has announced his intention to found three fellowships for scientific research to be held at the college. Mr. Beit's intention in founding these fellowships is to foster only the highest research. The fellowships will be limited to Europeans, men or women, who have graduated at universities in the British Islands, Colonies, and Dominions, or are recognised by the trustees to be of the same standing. The annual value of each fellowship is not to exceed 150*l*.—Prof. S. M. Dixon, professor of civil engineering at the University of Birmingham, has been appointed to the new chair in civil engineering in the City and Guilds (Engineering) College. The department in the City and Guilds (Engineering) College which has hitherto covered the subjects of civil and mechanical engineering will next session be divided into two departments, one dealing with mechanical engineering and motive power, under Prof. Dalby, and the other with civil engineering, including theory of structures, hydraulics and hydraulic machinery, ferro-concrete construction, docks, water supply, and surveying, under Prof.