describes his early experiments in telegraphy over a distance of a mile and a half. The equipment of the seismographic department of the geophysical institute is in every way unique, and the new earthquake house built by Prof. Wiechert in 1902 is probably one of the finest in the world.

It is beyond the scope of this article to go into detail on each of these developments, but a study of the volume shows that the facilities provided for the student at Göttingen appear to be fairly comparable in a general way with those now available at Manchester, where the splendid new laboratories of Prof. Schuster at the University, and of the College of Technology in the city, provide together all that could be desired for a complete course of training and research in almost any branch of either the pure or applied science. Though there is much at each of the two universities which cannot be compared to any similar thing at the other, yet many details make the resemblance between the equipments for pure physics distinctly striking; for example, each possesses a large concave Rowland grating, with mounting specially designed for accurate photographic work, made by Krupp and by Sir Howard Grubb respectively. The magnificent equipment at Manchester has already rendered excellent service in the hands of Mr. Duffield in his investigation of the effect of pressure on arc spectra.

The volume under review is well got up, and though considerable space is taken up with purely descriptive detail, there is much matter in it of real interest; for example, many passages in the speeches delivered at the opening ceremony sparkle in a manner not usual in such efforts. We conclude with a translation of some extracts from the address of Prof. Voigt. He says:—

"What is it, then, which fetters the crystallographer so strongly to his science? I will try to explain it by a parable.

"Let us imagine in a large hall a couple of hundred brilliant violin-players, who all play the same piece with instruments faultlessly tuned, but commence simultaneously at all sorts of different places, and perhaps at the conclusion begin over again. The effect is (at least for Europeans) not exactly pleasant, a monotonous jumble of sounds, in which even the finest ear is unable to recognise what is being played. . . . Such music the molecules of gaseous, liquid, and ordinary solid bodies make for us. They may be highly gifted molecules with marvellous internal architecture, but in their activity each disturbs the others. . . . A *crystal* on the contrary corresponds to the orchestra above described, when the same is led by a vigorous conductor, when all eyes intently watch his nod, and all hands follow the exact beat. . . This picture renders it understandable how crystals can exhibit whole ranges of phenomena, which are absolutely lacking in other bodies. . . . In my opinion the music of physical law sounds forth in no other department in such full and rich accord as in crystal physics."

J. A. HARKER.

THE ETIOLOGY OF SLEEPING SICKNESS.[1]

AMONG the scientific achievements of the last decade, few have been so remarkable as the rapid increase of knowledge with regard to the minute animacules termed by zoologists Protozoa. More especially is this true as concerns the parasitic members of the group and their relation to disease in man and beast. It is now known that protozoan parasites are the cause of many diseases, especially in the tropics, and as a type of such we may refer to malaria, since the etiology of this disease is now so thoroughly known that it may serve as a model, as it were, of diseases due to Protozoa, and at the same time furnishes valuable analogies and suggests the problems to be investigated in other cases.

The classical researches of Laveran, Ross, and others have resulted in establishing clearly the cause and nature of malaria, and have proved definitely (1) that the illness is due to a minute protozoan parasite present in the blood and multiplying there; (2) that the disease is transmitted from sick to healthy persons by certain biting gnats or mosquitoes, a mosquito which has sucked blood from an infected person being capable, after a certain period of time, of inoculating other persons with the malarial parasite at subsequent feeds; and (3) that the parasite is not carried merely passively by the mosquito, but passes through an essential part of its life-cycle within it, since sexual forms of the parasite are developed which conjugate and multiply in the digestive tract of the mosquito in a manner different from the mode of multiplication in the blood of the patient. It is not extraordinary that diseases of this type should be especially prevalent in the tropics, where insect life is so richly developed, and the numerous blood-sucking insects of all kinds furnish the requisite means of transmitting and disseminating the parasitic micro-organisms.

Since Livingstone's time it has been known that horses and cattle in Africa die from a disease produced by the bites of the indigenous tsetse-flies. These flies, of which eight species are now known, belong to the genus Glossina, a genus of Diptera or two-winged flies characteristic of the African fauna, and not found on other continents. The disease which they produce, termed nagana, or tsetse-fly disease, is rapidly fatal to imported cattle or horses, but does not affect human beings. Various suppositions were put forward as to the nature of the malign power exerted by the dreaded tsetse-fly until the discoveries of Bruce solved the problem once and for all. Bruce found that the disease is caused by the presence in the blood of a minute flagellated organism belonging to the genus of parasitic Protozoa already known to zoologists by the name Trypanosoma, and that the parasite is transmitted from sick to healthy animals by the bite of the tsetse-fly, which was thus shown to play a part in the dissemination of nagana analogous to that played by the mosquito in the dissemination of malaria. Bruce's researches established for nagana the first two propositions stated above for malaria, but it remained to be proved whether the parasite did or did not undergo a definite developmental cycle in the tsetse-fly, as the parasite of malaria does in the mosquito. Bruce discovered, however, another fact of great importance, namely, that the "trypanosomes" of nagana are to be found in the blood of indigenous wild game, such as antelopes and buffaloes, to which the parasites appear to be innocuous. These infected wild animals serve, however, as a reservoir for the disease, the trypanosomes being conveyed by the tsetse-fly from the indigenous wild animals to the susceptible domestic animals. No such natural "reservoir" has been proved as yet for the malarial parasite, though its existence has often been suspected.

It had long been known that negroes from the west coast of Africa were liable to a slow but fatal disease, which, from the peculiar comatose symptoms seen in the final stages, was termed the sleeping sickness. Nothing was known as to the nature of this

[1] "*Glossina palpalis* in its Relation to *Trypanosoma gambiense* and other Trypanosomes (Preliminary Report)." By E. A. Minchin, A. C. H. Gray and the late F. M. G. Tulloch. With 3 plates, 1 map and 11 text-figures (Proc. Roy. Soc., 1906.)

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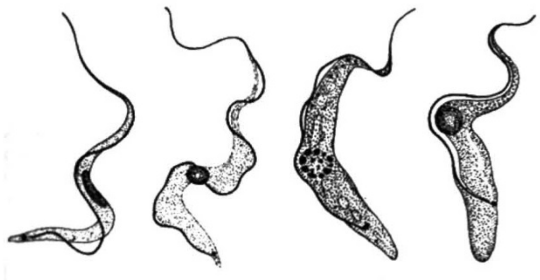
mysterious malady until quite recently, when it made its appearance in epidemic form in Uganda, producing an enormous mortality among the natives, and also attacking Europeans. The outbreak of the disease was so serious and threatening that, at the request of the Government, the Royal Society sent out a commission to investigate the nature of the disease, and to discover, if possible, the means of checking the further spread of the epidemic. The commission was not long in obtaining important results. It was discovered that the cause of the disease was a trypanosome which in the early stages of the malady was present in the blood of the patient, but which later penetrated into the cerebro-spinal fluid, and then gave rise to the comatose symptoms characteristic of the disease. It was further proved, once again by Bruce, that the parasite was transmitted from sick to healthy persons by the local species of tsetse-fly, *Glossina palpalis*, and that the sleeping sickness was, in fact, a human tsetse-fly disease comparable to the nagana of cattle, though caused by a different species of trypanosome transmitted by a different species of tsetse-fly, and differing further from nagana in the nature of the symptoms produced. It remained to investigate the exact relation of the parasite to the fly, that is to say, whether the trypanosome went through a developmental cycle in the tsetse-fly or not. It may be added that in the case of sleeping



a b c d

FIG. 1.—*Trypanosoma gambiense* from the intestine of the tsetse-fly, twenty-four hours after feeding upon an infected subject. *a* and *b*, male forms; *c* and *d*, female forms. ×2000 diameters.

sickness no natural "reservoir" has yet been discovered.

Early in 1905 the present writer was sent out to Entebbe by the Royal Society in order to investigate the exact nature of the relationship between the trypanosome of sleeping sickness, *T. gambiense*, Dutton (=*T. castellanii*, Kruse), and the tsetse-fly *Glossina palpalis*. At the time of commencing this work the state of knowledge was as follows:—The experiments of Bruce and Nabarro had proved that the tsetse-fly was capable of transmitting the parasitic micro-organism from an infected animal to one free from the infection if fed on the first, then on the second, with not more than forty-eight hours' interval; and, further, that tsetse-flies freshly caught in localities where sleeping sickness is rife, such as Entebbe, were capable of infecting healthy animals. Trypanosomes had also been observed to be present not infrequently in the digestive tract of freshly-caught flies, occurring in enormous numbers in certain regions of the intestine. Special interest attached, naturally, to these "wild" trypanosomes, as they may be termed briefly, meaning thereby trypanosomes with which the fly had become infected in nature, and not as the result of being fed in the laboratory on infected animals. Lieuts. Gray and Tulloch, of the sleeping sickness commission, had made detailed observations on the wild trypanosomes, and had found them present in about 1.8 per cent. of tsetse-flies caught at Entebbe. The wild trypanosomes differed considerably in appearance and structure from those found in the blood or cerebro-spinal fluid of sleeping-sickness patients, but not more than was capable of being explained as the result of developmental changes.

At that time the late Dr. Fritz Schaudinn had just published his well-known memoir on the life-cycle of the trypanosome of the little owl, *Athene noctua*, a work which created considerable stir among all workers upon Protozoa. We were, therefore, all fully prepared to discover complicated life-cycles involving great morphological changes in these organisms, and had little doubt but that observation would reveal a developmental cycle in the tsetse-fly analogous to that of the malarial parasite in the mosquito. It was, moreover, reasonable to suppose that the trypanosomes found in tsetse-flies caught in Entebbe would be the trypanosomes of sleeping sickness, since, as already stated, it had been proved experimentally that infection could be brought about by the bites of freshly-caught flies. When, therefore, we—that is, the present writer working in collaboration with Messrs. Gray and Tulloch—embarked upon these in-

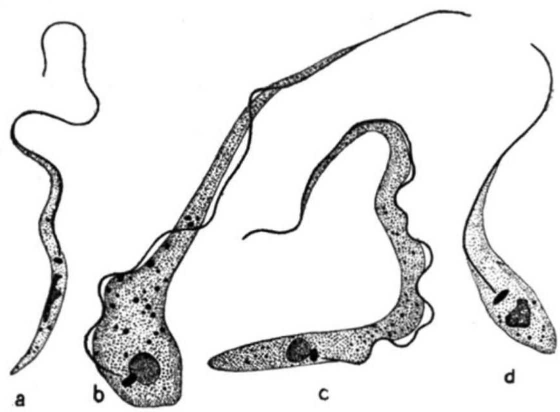


FIG. 2.—*Trypanosoma grayi* from the intestine of the tsetse-fly. *a*, male *b*, female; *c*, indifferent; and *d*, young forms. ×2000 diameters.

vestigations, we were fully convinced that the wild trypanosomes found in the tsetse-fly were nothing more than stages in the developmental cycle of *Trypanosoma gambiense*, and that it remained to work out this cycle in full detail and to refer the various forms of wild trypanosomes to their place in it.

The methods by which this problem was attacked were partly experimental, partly observational. By both alike, all attempts to establish a relationship between *Trypanosoma gambiense* of sleeping sickness and the wild trypanosomes occurring naturally in the tsetse-fly gave absolutely negative results, and forced us gradually and reluctantly, but irresistibly, to the conclusion that the wild trypanosomes of the tsetse-fly have no connection whatever with sleeping sickness, but belong to other species quite distinct from *T. gambiense*, and innocuous to man.

One series of experiments had for its object to determine the exact manner in which the tsetse-fly carries the trypanosome of sleeping sickness from an infected to a healthy animal. If the parasite passed through a developmental cycle in the tsetse-fly, it might be expected that the latter would show a certain periodicity in its infectiveness; that is to say, that

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after the fly had taken up the parasites, it would not be ripe, so to speak, to infect a healthy animal until after a certain period of time or a certain number of feeds, as is known to be the case with the mosquito in the transmission of malaria. To test this, and to discover the period necessary for the supposed cycle, batches of flies were fed first on an infected animal and then at regular intervals on a succession of healthy animals (monkeys), using a new healthy animal for each feed. In no case was an infection obtained later than forty-eight hours, although the experiments were extended over three weeks.

On the other hand, conclusive evidence was obtained of the existence of what may be termed direct mechanical infection; that is to say, if a tsetse be allowed to have a partial feed on an infected animal and be then transferred at once to a healthy animal, on which it is allowed to finish its feed, the second animal may become infected. This confirms the results previously obtained by Bruce, both for nagana and sleeping sickness. The experiment was varied by making the fly feed first on an infected animal and then on two healthy animals in rapid succession; it was then found that the first healthy animal became infected, but not the second. If the tsetse dips its proboscis for an instant into the skin of a healthy animal, it appears to clean the proboscis and render the fly non-infectious to other animals. This indicates that the direct mechanical transmission is effected by the proboscis alone. As is well known, if a tsetse-fly be fed on an infected animal, then decapitated, and its proboscis examined under the microscope, the cavity of the proboscis is seen to contain blood corpuscles and active trypanosomes, a fact which sufficiently explains the direct transmission. The experiments suggest that a tsetse which has fed on an infected subject is only infectious to the first healthy subject bitten by it afterwards.

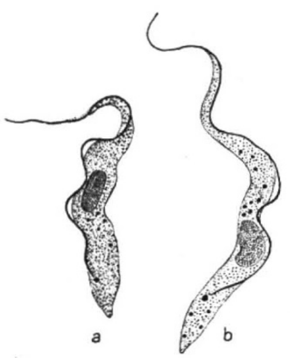

FIG. 3.—*Trypanosoma tullochii* from the intestine of the tsetse-fly. ×2000 diameters.

A second series of experiments had for its object to test the connection, if any, between the wild trypanosomes and sleeping sickness. An island called Kimmi, not far from Entebbe in the Victoria Nyanza, was found to teem with tsetse-flies to a degree almost incredible to anyone who has not been there. Although this island was uninhabited and hardly ever visited by human beings, it was found that the tsetse-flies there were more often infected with trypanosomes than on the mainland, since on the average between 7 per cent. and 8 per cent. of Kimmi flies were found to harbour trypanosomes, as against 1·7 per cent. from the neighbourhood of Entebbe. The island of Nsadzi, adjacent to Kimmi, was found to be free from tsetse except in certain limited spots along the shore, and hence served as convenient ground for a camp and station for experimenting upon the flies of Kimmi. The method was to feed a batch of flies caught at Kimmi upon a given healthy experimental animal daily for a certain length of time, then, by dissection and microscopic examination of every fly in the batch, to find out how many of them contained trypanosomes. In this way it was possible to make certain that animals susceptible to sleeping sickness had been fed upon by one or more tsetse-flies containing trypanosomes. Had these wild trypanosomes been identical with those of sleeping sickness, it might have been expected that some at least of the experimental animals would have become infected; but not in a single case did this occur. Attempts to infect experimental animals by direct inoculation of trypanosomes from the intestine of the fly proved equally futile.

The microscopical observation of the trypanosomes within the tsetse-fly led to similar conclusions. If tsetse-flies were fed on animals infected with *Trypanosoma gambiense*, and subsequently dissected and examined after various intervals, it was found that the trypanosomes flourished and multiplied for the first twenty-four hours, becoming at the same time differentiated into two distinct types, the one slender, transparent, and active, the other bulky, granular, and sluggish in movement. Compared with what is known of developmental phases in other Protozoa, the slender forms may be called male (Fig. 1, *a*, *b*), the bulky forms female (Fig. 1, *c*, *d*). Up to forty-eight hours the multiplication continues, and a more "indifferent" type of individual appears. At seventy-two hours, however, the trypanosomes have become greatly diminished, and by ninety-six hours, or slightly later, the trypanosomes have disappeared completely from the gut of the tsetse-fly, this disappearance coinciding with the complete absorption of the blood with which they were taken in. *Trypanosoma gambiense* appears, in short, to have very limited powers of maintaining its existence in the gut of the tsetse, and to be unable to pass forwards into the blood ingested at feeds subsequent to that at which it was taken up by the fly.

In the case of the wild trypanosomes, on the other hand, a very different state of things is found to exist. A study of the forms found in different flies shows that two distinct types occur, one or the other usually being present, though exceptionally both may be found together in the same fly. One of these types, which Novy has named *Trypanosoma grayi*, is distinguished in all its phases by the relatively large size of the smaller mass of chromatin (micronucleus or blepharoplast), which is elongated in a direction transverse to the axis of the body, and placed almost invariably in front of the nucleus (Fig. 2, *a*–*d*). The other type, which we have named *T. tullochii*, is more like *T. gambiense* in its characters, having a small rounded blepharoplast placed well behind the nucleus (Fig. 3, *a*, *b*). Both these types are remarkable for their very great activity, whereby they swarm forwards in the gut of the fly into the blood ingested by it at each feed, and by their own exertions penetrate from the hindmost portion of the gut into its most anterior regions.

The conclusion drawn from these observations is that the "wild" trypanosomes, those found occurring naturally in the tsetse-fly at Entebbe, are not stages of the trypanosome of sleeping sickness, but represent at least two entirely distinct species. It remains to be discovered whence the tsetse-fly obtains these trypanosomes. It may be that the tsetse obtains them from the blood of indigenous animals upon which they are parasitic; *Trypanosoma grayi* has some resemblance to certain trypanosomes of birds, while *T. tullochii* is more of the type of a mammalian trypanosome. It may be, on the other hand, that they are parasites of the fly itself, and have no other host of any kind.

With regard to *Trypanosoma gambiense*, experiment and observation alike show that in Uganda it does not pass through a developmental cycle in the tsetse-fly, but is only transferred mechanically by the

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fly's proboscis. But the manner in which this trypanosome at first multiplies and develops into male and female forms in the fly's intestine is very remarkable, and suggests the commencement of a life-cycle which is not completed, but which might be so under other conditions. In the case of the trypanosomes of fishes, Brumpt has shown that a given species will go through a complete development in a particular species of leech, but only through a part of the development in another species of leech. There may be conditions, therefore, in which *T. gambiense* would complete the developmental cycle which is seen to begin, but appears to be inhibited, in the tsetse-fly in Uganda. It must be borne in mind that the sleeping sickness is a new thing, apparently, on the Victoria Nyanza, and has broken out there comparatively recently in epidemic form.

In conclusion, there remains only the sad duty of referring to the untimely death of the youngest of the three collaborators in this work, who became himself in some way infected with the trypanosomes which he was studying, and passed away before the results of the investigation were published. Only those who knew Forbes Tulloch can gauge the loss and bereavement occasioned by his tragic end.

ὁ Δαφνὶς ἔβα ῥόον· ἔκλυσε δίνα
Τὸν Μώσαις φίλον ἄνδρα.

E. A. MINCHIN.

THE WIRELESS TELEGRAPHY CONFERENCE.

THE second International Conference on Wireless Telegraphy, which has been sitting during the past few weeks at Berlin, concluded its labours on Saturday, November 3, when the first "Convention radiotélégraphique internationale" was signed by all the representatives of the Powers. The States which have signed the convention are the following:—Great Britain, Germany, the United States of America, Argentina, Austria-Hungary, Belgium, Brazil, Bulgaria, Chili, Denmark, Spain, France, Greece, Italy, Japan, Mexico, Monaco, Norway, the Netherlands, Persia, Portugal, Rumania, Russia, Sweden, Turkey, and Uruguay.

The first conference, which, it will be remembered, was only of a preliminary nature, was held in Berlin in August, 1903, and a summary of the results then attained was given in NATURE at the time (NATURE, vol. lxviii., p. 437). It was there pointed out that by far the most important resolution which the conference had to consider was that making it compulsory on all coastal stations to receive from and transmit to ships at sea all messages irrespective of system, and the hope was expressed that private interests would not be allowed to stand in the way of the development of one of the most beneficial of the recent practical applications of science. Three years have passed since that conference was held, but the correspondence and articles which have lately been so prominent in the daily Press show that this period has served neither to allay private jealousies nor to enlighten public opinion on the true merits of the case; the same appeals to ignorance and prejudice have been made now by both parties to the dispute as were made then.

As the whole question of the justice or injustice of the provisions of the present conference turns on the claims of Signor Marconi, it will not, perhaps, be out of place to recapitulate very briefly the early history of wireless telegraphy. In using the expression "wireless telegraphy," we use it in the sense now almost universally accepted of telegraphy by Hertzian waves, as any consideration of earth conduction or magnetic induction methods has naturally nothing to do with the present conference. The foundations of wireless telegraphy were laid, as everyone knows, by Clerk Maxwell in the theory which gave rise to the experimental researches of Hertz. At the Bath meeting of the British Association in 1888, when the results of Hertz's work were brought to the notice of British men of science by Prof. Fitzgerald, some experiments by Sir Oliver Lodge on the same subject were also described which showed that he was within an ace of making the same discoveries himself. For some time after this experimental work was chiefly devoted to the confirmation and extension of the work of Hertz. It was early recognised that there were possibilities about the new discovery which might render it a useful means of telegraphic communication, and suggestions to this effect appeared in 1891 in *The Electrician*, and in 1892 in the *Fortnightly Review* (from the pen of Sir William Crookes).

The practical application of Hertz waves to telegraphic purposes needed, however, the invention of a delicate detecting mechanism. What Lord Kelvin did for submarine telegraphy by the invention of the syphon recorder, Lodge and Branly did for wireless telegraphy by the invention of the coherer (1889–1891). From this time onward progress was rapid. In 1894 Sir Oliver Lodge demonstrated at the Royal Institution the transmission of signals over considerable distances and through several obstacles. But the credit for first establishing the practical utility of the system, for demonstrating that it was not merely a new scientific toy, lies with Signor Marconi, and to his energy and perseverance we owe it that wireless telegraphy as an art was born in 1896. To his energy, also, and to that of those associated with him, we undoubtedly owe, not only the most extended system of wireless telegraphy of to-day, but also to a large extent the extension of other systems which but for his lead would never have reached their present development. Yet no student of scientific progress can doubt for a moment that if Marconi had not stepped in at the critical point some other would have taken his place. The work of the true pioneers was done, the way into the new country was discovered, and it remained only for the most energetic and resourceful to till the virgin soil and reap the plentiful harvest.

Now that the reaping of the harvest is in sight we are confronted with the rival claims of the sowers. With a wisdom characteristic of the times, the Powers have decided that though each may sow and reap for himself, he shall conduct his operations in the way most advantageous to civilisation. This decision is embodied in the third article of the convention, which provides that "coastal stations and stations on shipboard are bound to interchange telegrams without distinction of the system of wireless telegraphy adopted by them." On behalf of the Marconi Company it has been urged that this provision was devised with the express purpose of obtaining for all systems—and especially the Telefunken system—the immense advantages of the Marconi Company's extended organisation. On the other hand, there could be no other reason for objecting to this clause than a desire on the part of the objector to establish a monopoly. As was pointed out in the article in NATURE to which reference has already been made, the peculiarities of wireless telegraphy render it essential for public utility that there should be either a world monopoly or a perfectly free interchange between competing systems. It is not difficult to choose between these alternatives, and no one, we venture to think, ten years hence will question the correctness of the decision now made.

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