THE ETIOLOGY OF YELLOW FEVER.

YELLOW fever is an acute infectious disease, endemic in the West Indies, the shores of the Mexican Gulf, and in some parts on the West Coast of Africa, whence the disease has been repeatedly transported into other localities, causing here epidemic outbreaks. Like other infectious diseases, yellow fever is supposed to be caused by a specific living entity which, invading a predisposed person, multiplies there and causes the peculiar pathological changes in the gastrointestinal tract and the liver, characterising yellow fever. Within recent years the supposed specific microbe has been discovered several times. Dr. Domingos Freire, of Brazil, and Dr. Carmona y Valle, of Mexico, have announced such discovery, but Dr. Sternberg, of Washington, who has himself studied the disease on behalf of the United States Government, has shown that none of these discoveries are a reality, and after a prolonged investigation, including the examination of a great many cases affected with, or dead from the disease, has arrived at the following conclusions, embodied in a lengthy report to his Government: that none of the different species of bacilli and cocci, present in the intestinal canal, in the blood, the liver and other tissues of persons affected with yellow fever, can have a claim to be considered as the specific microbe; that in a number of cases the examination, microscopic and cultural, of the blood and tissues yielded no bacteria recognisable either by the known methods of staining or culture; and he finally implied that the specific microbe of yellow fever is most probably not of the nature of a bacterium at all. After these very definite conclusions by Dr. Sternberg, it came rather as a surprise when, some months ago, the announcement was made that Dr. Sanarelli, Professor of Experimental Hygiene in Montevideo, formerly in the Pasteur Institute in Paris, had discovered the true cause of yellow fever in the form of a bacillus, *Bacillus icteroides*. This surprise is still further heightened by the statement in Dr. Sanarelli's lecture, that the *Bacillus icteroides* is demonstrable by the ordinary methods of staining and by culture in the ordinary well-known media. The morphological and cultural characters of the bacillus show it to belong to the group of coli-like bacilli; it is rarely demonstrable in a pure state in the blood or tissues, being generally associated with a more or less copious admixture of other microbes—*Bacillus coli communis*, *streptococci* and *staphylococci*; as a rule it is present only in small numbers in the capillary blood-vessels of the liver, spleen and kidney. It reflects great credit on the perseverance and sagacity of Dr. Sanarelli to have been able, notwithstanding all these difficulties, to select out the *Bacillus icteroides*, and to have by animal experiment been able to demonstrate, at least, as highly probable that the *Bacillus icteroides* is the true microbe of yellow fever. As mentioned just now, the distribution of the microbe in the affected person, its morphological and cultural characters do not in themselves offer strong *prima facie* evidence, and Dr. Sanarelli himself fully recognises this; but when we come to the experimental evidence which he furnishes, the evidence as to the *Bacillus icteroides* being the specific cause of yellow fever assumes considerable power.

In the first place, Sanarelli shows that dogs, goats, and horses are susceptible to infection both with the living bacilli as also and particularly with the highly poisonous toxin produced by the bacilli in broth culture; the symptoms and anatomical lesions hereby produced in these animals in the intestinal tract, the liver and the kidney, bear a striking resemblance to those of yellow fever in man. In the second place, Sanarelli furnishes proof that the toxin produced in broth culture—and separated from the bacillary growth by filtration through a Chamberland filter—when injected into healthy persons

causes a prompt reaction in the form of severe disturbance, primarily of the intestinal tract, but also, further, of the general system closely resembling that in yellow fever. It is to be hoped, nay, it may be assumed as certain, that in continuing his investigations Dr. Sanarelli will ascertain the action of the blood of human beings, who have passed through, and recovered from the disease, on the *Bacillus icteroides*. This disease, as is well known, very rarely occurs twice in the same person, and it is therefore highly probable that, as is the case in other similar infectious diseases, the blood after a single attack possesses agglutinating action (*in vitro*), or germicidal action (*in corpore*), or both on the culture of the specific microbe. If on further investigation the blood serum, after an attack of yellow fever, should be found to show such positive actions on the *Bacillus icteroides*, a strong support will thereby be furnished as to this bacillus being the specific microbe. It will be the crowning of prolonged and laborious studies, if Sanarelli by experiments on immunisation of animals—the horse being evidently well fitted for such immunisation—did, as is highly probable that he will, obtain antitoxic serum by which yellow fever can be successfully combated both prophylactically and therapeutically. E. KLEIN.

THE VARIABLE STAR η AQUILÆ.¹

THIS essay contains a full discussion of all the available observations of a remarkable variable star, the fluctuation of whose light presents many features the explanation of which is still beset with much difficulty. Of the 12,000 recorded comparisons of the relative brightness of η Aquilæ and neighbouring stars, no less than 7147 are due to the indefatigable perseverance of Julius Schmidt, who for the last twenty years of his life (1859-1879) was director of the observatory at Athens. Taking advantage of the preponderance of Schmidt's records over those of all other observers, the author first investigated the variations of the star's light as shown by these alone, and then examined in how far the results thus obtained were confirmed by the labours of other observers. The discussion of Schmidt's observations was complicated by the circumstance that in the majority of cases he only used two comparison stars, β and ι Aquilæ, one of which there was great reason to believe was itself variable. From the 1700 occasions on which both stars were used, Dr. Lockyer found ι to vary 1.7 grades of Schmidt's scale with a period of about thirty-five years. Associated with this long-period change, the relative brightness of ι was shown to be subject to an annual variability of about one grade, which is clearly traced to the influence of the hour angle at which the stars were compared. This apparent annual variation is, therefore, identical with the "position error" noted by many observers of variable stars, and which has lately been investigated so thoroughly by Mr. Roberts, of Lovedale, South Africa. Schmidt's observations, freed from both the above variations as well as from the slight aberration error due to the changing position of the earth in its orbit, were all reduced to the meridian of Bonn. Owing to the general sparseness of the data, it was necessary to combine the observations of 100 periods, or about two years, into a group represented by a single curve. This was effected with the help of a provisional mean period and date of minimum for which Argelander's values of 7d. 4'23444h. and 1848, mag. 18d. 6'4333h. M.T. at Bonn were adopted, the date being that of epoch 400. To further facilitate the construction of the curve the mean

¹ "Resultate aus den Beobachtungen des Veränderlichen Sternes η Aquilæ." Inaugural Dissertation zur Erlangung der Doctorwürde, von William J. S. Lockyer. 5 plates, quarto, pp. 95. (Göttingen: 1897. London: Dulau and Co.)

brightness in each 6-hour interval of the period was set down for each group, together with the corresponding time and the number of observations. In this way the whole of the materials collected by Schmidt from 1844 to 1879, and thus covering eighteen groups of 100 periods each, are expressed in tabular form on p. 21 of Dr. Lockyer's dissertation. The numbers for each period were then plotted on millimetre paper; tentative and afterwards definite curves representing the fluctuations of the star's light were drawn through the points thus obtained. The resulting eighteen curves representing Schmidt's observations are reproduced one above the other on a small but distinct scale on Plate I., each curve being prolonged by about one-third of the period to bring out the form of the minimum. A study of these curves shows that Argelander's period cannot, at present, be improved on as a mean value. The time of Argelander's epoch 400 is, however, shown to be too early by an interval which the author fixes at 3.2655 hours. The curves also show conclusively that the epoch of maximum oscillates to and fro to the extent of five hours on either side with a period comprising 400 maxima. In the same way the minima are subject to an oscillation of about three hours in approximately 2400 periods. The combined effect of these variations causes the light-period to vary between 7d. 4h. 14m. 40s. and 7d. 4h. 13m. 28s. also in 2400 periods. Superposed on the main light curve are four subordinate undulations, of which more hereafter.

Much the same method was followed with regard to the observations of Argelander, Schönfeld, Heis, Plassmann, Oudemans, Pannekoek, Auwers, Knopf, Sawyer and Schur; but with the further step of reducing the estimated grades to Argelander's scale. This reduction, carried out with scrupulous care by the method of least squares, brings out several interesting facts regarding the values which the grade, or unit of brightness, assumes in the case of the different observers, or for the same observer at different times. Here there is only space to mention the observations made by Knopf in Jena. Contrary to the general usage of comparing a variable with stars differing from it in brightness by at most five or six grades, Dr. Knopf often allowed himself a range of no less than nineteen grades. This new departure has most unexpectedly had no injurious effect on the accuracy of the observations, as is abundantly proved by the smallness of the residuals in the evaluation of the brightness of the comparison stars. From the materials collected by the observers just named, the author constructed nineteen further curves, which confirm in a high degree the results from Schmidt's observations alone. Dr. Lockyer also tests the accuracy of his conclusions by means of the long series of observations made by Wurm in the course of twenty-seven years, beginning with 1785. The detail, indeed, of these observations seems never to have been published, but the actual length of the period in accordance with Schmidt, for the epoch of Wurm's observations, differs but seven seconds from Wurm's value; and since the early observations also show decided indications of the oscillation of the time of maximum, it seems certain that the general character of the variability of η Aquilæ has not materially changed in the course of the last hundred years.

As regards the four secondary fluctuations, they are found to recur at intervals of forty-three hours, or one quarter of the main period, the first of these secondary maxima occurring fifteen hours after the chief minimum. The author is the first to have clearly brought out this feature, and he explains it by assuming, in accordance with his father's hypothesis, that the system of η Aquilæ consists of three meteoric swarms, of which the two lesser revolve about the greater in periods of 1d. 19h. + and 7d. 4h. + respectively (see "Meteoritic Hypothesis,"

passim, but particularly pp. 475-6). The irregularities in these fluctuations are set down to the perturbations necessarily occurring in such a system, but their investigation did not come within the scope of the essay before us. Figs. 1 and 2 of the dissertation show the proportions of the assumed orbits, together with the form of the light curve resulting from the combination of the two elementary curves. In conclusion, I must express my admiration of the skill and untiring perseverance which Dr. Lockyer has shown in dealing with a large mass of somewhat intractable material. Wherever possible the deductions were made from the original manuscripts, concerning which interesting particulars are given on pp. 19 and 20, where we learn that Schmidt's original notes are preserved at Potsdam, while those of Heis have wandered across the Atlantic to the observatory of Georgetown College.

R. COPELAND.

BRITISH ASSOCIATION TORONTO MEETING.

III. LOCAL ARRANGEMENTS.

THE two leading Hydraulic Companies of Niagara Falls are making special arrangements for the reception of the members of the British Association.

The Carborundum Company of Niagara Falls has extended an invitation to the members of the Association to visit and inspect the Company's works on Saturday, August 21. The manufacture of carborundum by this Company has been fully described in NATURE for May 13 (p. 42).

The Atlantic Cable Companies have generously arranged that members from Great Britain may send two free cable messages from Toronto, and they will then be entitled to two free replies. Each message and reply are not to contain more than ten words each, and they are to be forwarded by agents recognised by the Cable Companies. The agents in Great Britain will, in all probability, be Messrs. Cook and Son, and in Toronto the Honorary Local Secretaries; but the arrangements in regard to this are not complete, and a fuller announcement will be made later. It is to be noted that the transmission of the messages within Great Britain to and from the head office of Cook and Son will be charged for as ordinary telegraphic messages. The arrangements in this respect are the same as those made in 1884.

In order to avoid delay in the Customs examination of the members' luggage, the Hon. Mr. Paterson, the Minister of Customs, has given special instructions to the Customs officers at Quebec, Montreal and Niagara to facilitate in every way the examination. A larger number of examining officers will be on duty at Quebec, and one will accompany each steamer from Quebec to Montreal to make the examination of the luggage during the passage. As a result of this arrangement, all delay at Quebec and Montreal will be avoided. The Minister of Customs has also arranged that all scientific apparatus or material for use during the meeting of the Association shall be admitted free of duty if forwarded to me at Toronto, and marked, "For British Association."

It is expected that there will be in attendance at Toronto more than twenty continental men of science of a representative character. Amongst those who have intimated their intention to be present are Prof. Charles Richet, Prof. Yves Delage, both of Paris; Prof. Meslans, University of Nancy; Prof. Gilson, of Louvain; Dr. van Rijkevorsel, of Amsterdam; Dr. Pauli, of Frankfurt; Prof. Ladenburg, of Breslau; Prof. Runge, of Hanover; Prof. Brauner, of Prag; Prof. Penck, of Vienna; M. Letourneau, of Paris; M. Gobert, of Brussels; and Prof. P. Magnus, of Berlin.

A. B. MACALLUM.