above the valve. The mercury in the pump is raised or lowered by applying atmospheric pressure or suction to the flask. The suction necessary to operate the pump is obtained by a small water-jet pump giving a vacuum of about 28 inches. A pump with the valve alone will work fairly well, except that occasionally, when the quantity of air taken out at each stroke becomes small, a little bubble will cling to the valve and refuse to pass out of the pump. To avoid this, a trap is added below the valve to prevent any air which might fail to pass the valve from returning to the pump.

The only requisite to make the pump automatic is to have some means of controlling a three-way cock which will apply either pressure or suction to the flask. This control is obtained electrically by making and breaking a circuit in the valve at the top, and in a float in the flask at the bottom. A permanent electrical connection is made with the mercury in the flask at the bottom. A platinum wire sealed into the tip of the valve serves to connect electrically the mercury in the valve with that in the pump. An iron wire dips into the stem of the valve and serves as a final contact. The mercury rising in the pump first makes contact with the inside of the valve through the platinum wire. As it continues to rise the valve opens floats and completes the circuit by the iron wire. It will be seen that the final contact is made in the valve, and any sparking that may occur can in no way foul the mercury in the pump. When the mercury in the pump reaches its lowest level a float in the flask similar to the valve at the top closes another circuit. These two circuits control a relay which in turn controls a solenoid connected to the three-way cock. The solonoid is wound for 110 volts and takes only a small current. One or two Leclanché cells are sufficient for the relay. The electrical connections are shown in the figure.

A pump of this form has been in use at the Massachusetts Institute of Technology for over two years, and has proved very satisfactory. It works quickly, and will give high Crookes vacuum without trouble.

In starting the pump, the pump and whatever may be attached to it are first exhausted by the water pump to about two or three inches' pressure. For the first few strokes, which are make by hand, the mercury is allowed to rise only part way in the pump. After this the necessary electrical circuits may be closed and the pump will take care of itself. In this way the dangerous hammering of the mercury occurring when the quantity of air taken out at each stroke is large can be avoided.

I am indebted to Mr. C. L. Norton for valuable assistance in developing this pump.

RALPH R. LAWRENCE.

ROGERS LABORATORY OF PHYSICS,
MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

SCIENTIFIC BOOKS.

The Wonderful Century. By ALFRED RUSSELL WALLACE.

As the human mind is more wonderful than anything else that we find in nature, so the greatest and most significant difference between the 'Wonderful Century' and all that had gone before is an intellectual difference.

It is not invention and discovery and the extension of man's dominion over nature, but the establishment of the conviction that we know no limit to this movement, that is the chief distinction of our century.

Among those who have, in our day, guided the thoughts of men to this conviction, future historians will give the highest place to Lyell, and Wallace and Darwin; for no one in our century has done more than they to assure us that the scientific method is adequate; even if successive generations of 'philosophers' still continue to teach that the very top and perfection of human wisdom is the assertion that we know, and can know, nothing.

With modesty which some hold to do him less than justice, Wallace believed that Darwin so much surpassed him in strength and wisdom and in acquaintance with nature that it became his duty to devote his life to the assistance of Darwin in his efforts to extend the province of human knowledge into regions that had been declared closed. The intellectual revolution has come about, nor will the thoughtful permit Wallace's part in bringing it about to be forgotten; nor can we forget the generous devotion which chose the advancement of truth before the natural desire for recognition and distinction. No one can suspect that such a man as Wallace has proved himself will ignore or depreciate the share of anyone in this great work, and few chapters of his book on 'The Wonderful Century' are more interesting than the one in which he touches, very gently and tenderly, upon the part which the 'philosophers' have had in the progress of natural science.

It is one thing to show that there is no logical basis for belief that species are immutable, but it is quite a different matter to show what modifies species. It was by finding out, and not by exposing the weakness in the logic of those who asserted that we never can find out, that Wallace and Darwin passed the bounds where they had been told that natural knowledge ends.

Lamarck, and Chambers, and Herbert Spencer, and many others, even Wallace himself, had shown that there is no reason to doubt that species are mutable; but all had failed to show how the changes take place; and many eminent men of science, as well as the general public, refused to consider beliefs which were as yet beliefs and nothing more.

What educated public opinion was before the publication of the 'Origin' is shown, says Wallace, by the fact that neither Lamarck nor Herbert Spencer nor the author of the 'Vestiges' had been able to make any impression upon it. The very idea of progressive development of species from other species was held to be a 'heresy' by such great and liberal-minded men as Sir John Herschel and Sir Charles Lyell; the latter writer declaring, in the earlier editions of his great work, that the facts of geology are 'fatal to the theory of progressive development.' The whole literary and scientific worlds were violently opposed to all such theories, and altogether disbelieved in the possibility of establishing them. It had been so long the custom to treat species as special creations, and the mode of their creation as the 'mystery of mysteries,' that it had come to be considered not only presumptuous, but almost impious, for any individual to profess to have lifted the veil from what was held to be the greatest and most mysterious of Nature's secrets.

Wallace tells us, 'The Wonderful Century,' p. 139, that after he had studied what had been written, and even after he had himself written about the mutability of species: "I had no conception of *how* or *why* each new form had come into existence with all its beautiful adaptations to its special mode of life; and though the subject was continually being pondered over, no light came to me till three years later (February, 1858), under somewhat peculiar circumstances. I was then living at Ternate, in the Moluccas, and was suffering from a rather severe attack of intermittent fever, which prostrated me for several hours every day during the cold and succeeding hot fits. During one of these fits, while again considering the problem of the origin of species, something led me to think of Malthus' Essay on Population (which I had read about ten years before), and the 'positive checks'—war, disease, famine, accidents, etc.—which he adduced as keeping all savage nations nearly stationary. It then occurred to me that these checks must also act upon animals, and keep down their numbers; and as they increase so much faster than man does, while their numbers are always nearly or quite stationary, it was clear that these checks in their case must be far more powerful, since a number equal to the whole increase must be cut off by them each year. While vaguely thinking how this would affect any species, there suddenly flashed upon me the idea of *the survival of the fittest*—that the individuals removed by these checks must be, on the whole, *inferior* to those that survived. Then, considering the *variations* continually occurring in every fresh generation of animals or plants, and the changes of climate, of food, of enemies always in progress, the whole method

of specific modification became clear to me, and in the two hours of my fit I had thought out the main points of the theory."

If this had been only a fortunate guess it would have little interest, for no one cares to ask whether Empedocles, or Wells, or Mathew, or Darwin, or Herbert Spencor, or Wallace first had this happy thought. It was because Wallace had spent years of hard work in gathering facts and in pondering them that he was able to see that this sudden product of his 'fit' was worthy of further examination, and because he devoted the rest of his life to its application to new discoveries that he is held to be the joint discoverer of the law of Natural Selection.

The origin of species by means of natural selection is now universally accepted as a demonstrated principle. "This," says Wallace, "is, of course, partly due to the colossal work of Herbert Spencer; but for one reader of his works there are probably ten of Darwin's, and the establishment of the theory of the *Origin of Species by Means of Natural Selection* is wholly Darwin's work. That book, together with those which succeeded it, has so firmly established the doctrine of progressive development of species by the ordinary processes of multiplication and variation that there is now, I believe, scarcely a single living naturalist who doubts it. Probably so complete a change of educated opinion, on a question of such vast difficulty and complexity, was never before effected in so short a time. It not only places the name of Darwin on a level with that of Newton, but his work will always be considered as one of the greatest, if not the very greatest, of the scientific achievements of the nineteenth century, rich as that century has been in great discoveries in every department of physical science."

To this we must add that, so long as the 'Origin of Species' holds its place on the shelves of students, close beside it we shall find the 'Malay Archipelago;' for the writer of this review has no doubt that Wallace will be one of those to whom future generations will say: "Friend, Go up higher."

W. K. BROOKS.

JOHNS HOPKINS UNIVERSITY,
BALTIMORE.

The Principles of Bacteriology. By DR. FERDINAND HUEPPE. Translated by PROFESSOR E. O. JORDAN. Chicago, The Open Court Publishing Co. Pp. 455.

American bacteriologists certainly owe a debt of gratitude to Professor Jordan for putting into clear English this valuable contribution to the science of bacteriology of Professor Hueppe, of Prague. Hueppe's contribution to bacteriology in this volume is no ordinary one. The book is not simply a review of facts, but is decidedly original. From the first to the last the author and his opinions are decidedly in evidence. Whether or not one is inclined to agree with him in all his conclusions, no one will question the force of the arguments with which he upholds his opinions.

After giving some general information in regard to bacteria (in which the author accepts the conclusion that the tuberculous bacillus is not a bacterium at all) he deals in successive chapters with the vital phenomena of bacteria, pathogenic bacteria, the cause of infectious diseases, cure by combating the cause, immunity, prevention and history. The chapter upon vital phenomena of bacteria is especially valuable, since it treats, in a comprehensive manner, of the somewhat obscure subject of the chemistry of bacterial poisons and bacterial nutrients.

But the most suggestive part of the work begins with the chapter upon the cause of infectious disease. Here he sets himself in opposition to the school of Koch by denying that bacteria can in any proper sense be regarded as the cause of disease, and especially repudiating the idea that definite species of bateria are the 'specific' cause of 'specific' diseases. No one can question Hueppe's thorough acquaintance with the facts of modern bacteriology, and it seems a little strange that he can hold a position so generally at variance with that of most bacteriologists. But we soon learn that his position is not so different from that of Koch as at first appears, and perhaps not so different as Hueppe tries to make it appear. Hueppe is, of course, fully aware that diseases are produced in animals by inoculating them with certain bacteria cultures. His criticism is simply against the claim that they are the *cause* of the disease and