they are of apparently nearly uniform width throughout their length. What they are is another matter. Mr. Lowell thinks, however, that the mere aspect is enough to cause all theories about glaciation fissures or surface cracks to die an instant and natural death.

But it is their singular arrangement that is most suggestively impressive. They have every appearance of having been laid out on a definite and highly economic plan. They cut up the surface of the planet into a network of triangles instantly suggestive of design. What is more, at each of the junctions there is apparently a dark spot. This feature seems to be invariable, as, on closer approach, junction after junction turns out to have one. The larger of these appear on Schiaparelli's chart as lakes. But there would seem to be a small infinity of smaller ones. A short half-hundred of them were seen at Arequipa in 1892, and others have recently been detected at Flagstaff. For example, an important new canal, which runs from the western end of the sea of the Sirens to Ceraunius, and which in view of its point of departure Mr. Lowell is induced to call the Ulysses, passes through three of these small dark spots on the way, one at each junction. One of these was seen at Arequipa and elsewhere in 1892; the other two are new discoveries. The region of the Lake of the Sun is especially fertile in canals. In one of the drawings which accompanies the paper here summarised, thirty-one canals are to be seen, counting each line between junctions as a separate canal. Of these seventeen are among those in Schiaparelli's chart, while fourteen are not. Of the twelve lakes in the figure, five are not down on his chart. This is thought not, in general, to be the result of change, though changes there apparently have been after proper discount has been made for difference of observations and of drawing. First and foremost, the Golden Chersonese has vanished; the land of Ophir now forms the continental coast-line. Secondly, Icaria has entirely altered in contour, resembling now an open fan about the Phœnix lake for pivot. Phætontis has shrunk to one-third of its former width—as represented in Schiaparelli's chart. Eosphoros no longer enters Phœnix lake at the point opposite Pyriphlegethon, but farther to the west. But the strangest transformation of all is that of the Phasis, which has apparently obligingly become two (not geminated in the technical sense) to suit both the old and the new state of things. There is now a canal running in the same direction as the old Phasis, but not to the southern end of Phætontis; and there is another one running to the southern end of Phætontis, but not in the same direction as heretofore. This attempt to carry out two apparently important ends by self-multiplication is not a common characteristic of inanimate nature—a point which Mr. Lowell holds is worth consideration.

Mr. A. Stanley Williams contributes to the November *Observatory* an account of his observations of Mars up to October 20. With regard to the canals Mr. Williams says:—"By taking advantage of every favourable opportunity, fifty-one canals have been observed up to the present time [October 20]. These include most of those shown in Prof. Schiaparelli's latest map that could be properly observed at present, and in addition three others not marked in the map. Generally speaking there is no difficulty in certainly identifying the canals, with the exception of a few which are situated far north, and consequently are too close to the limb to be distinctly observed. The general accuracy of the map is very striking, and I have often been strongly impressed by the very thorough manner in which Prof. Schiaparelli's work has been done. It is most rare to come across the trace of a canal not marked in his map, and the positions of objects are usually very reliable."

In the October number of our contemporary, Mr. Williams stated that Phison was probably double. Later observations, however, have shown it to be only single, the apparent gemination being probably caused by the existence of a feeble, unrecorded canal running parallel to it, and about midway between it and the coast bordering the Kaiser Sea. Agathodæmon and Araxes were seen intensely double on three or four nights in September. Chrysorrhoas was also seen double, but this canal appeared as an inconspicuous object compared with Agathodæmon and Araxes. In September Mr. Williams saw Amenthes as a narrow inconspicuous and apparently single canal. At the beginning of October, however, the object appeared as a very broad, dusky, double canal. Ganges is another broad, conspicuous double canal, the duplicity of which, according to Mr. Williams, is so obvious as to be apparent on almost any night on which observations are possible.

Referring to the small dark spots designated lakes, Mr. Williams says:—"Several more of these curious dark spots have been seen. Lacus Phoenicis on a good night appears as a small, nearly round, almost black spot, resembling the shadow of a satellite of Jupiter when in transit. On one night a feebler companion spot was seen just preceding it. Lacus Tithonius is a similar definite and nearly black spot, with a feebler companion following it. In a fine drawing of Mars, dated September 5, Mr. Cammell shows Lacus Moeris as a minute dark spot, with Nepenthes as a narrow definite line, and so I have seen them on several nights lately. Lacus Tritonis is a similar spot. At the junction of the canals Amenthes (following component), Thoth, and Astapus, there is also a little dark spot. The dark spot at the north end of the Ganges, known as Lacus Lunæ, has been rather perplexing. On several nights there was an evident appearance of duplicity about it, though it was impossible to say with certainty in which direction it was double. At length, however, the mystery was cleared up, the lake having been seen distinctly double on September 29 at right angles to the direction of the Hydraotes. The streak or bridge dividing the lake into two was bright yellow."

The varying appearances presented during October by the Mare Cimmerium, and the extensive region lying to the north of it, leads Mr. Williams to think that a great development of cloud or mist has lately taken place on Mars. His observations suggest "that cloud and mist formations are much more extensive and common on Mars than is generally considered to be the case."

THE ELECTRIC CONDUCTIVITY OF PURE WATER.

THE difficulties besetting the preparation of water free from the last traces of dissolved impurity cannot be better illustrated than by the attempts which have been made to ascertain the electric conductivity of the pure liquid. At the outset it has to be remembered that the conductivity of water is exceedingly small. As the result of the most recent observations it has been found that one millimetre of water has at 0° almost the same resistance as 40,000,000 kilometres of copper of the same cross-section; consequently a copper wire having the same resistance and sectional area as one millimetre of water would be long enough to encircle the earth one thousand times. From the difficulty of preventing the introduction of small quantities of dissolved material into the water, and from the large diminution which such impurities exercise upon the resistance, there is probably no physical constant for which such widely varying values have been given as for the electric conductivity of water.

If the conductivity of mercury be taken as 10^{10}, prior to 1875, the following values had been ascribed to water by the observers named:—80, Pouillet; 70, Becquerel; 15, Oberbeck; 4·5, Rosetti; 2·16, Quincke; and 1·33, Magnus. In 1875, Kohlrausch succeeded in reducing the observed conductivity to 0·71, or a value only 1/120th of that given by Pouillet. The large diminution thus brought about was no doubt due, for the most part, to the improved methods employed in obtaining purer samples of water. In Kohlrausch's experiments pains were taken not only to remove organic matter and any volatile alkaline or acid impurities from the water, but also to ensure that in its subsequent treatment contact with glass was avoided, the purified water being distilled through a platinum condenser into a platinum resistance-cell. The next important modification in the treatment of the water was again introduced by Kohlrausch in 1884. The whole of the above measurements had been made upon water distilled under ordinary conditions, and thus in presence of air; he therefore proceeded to ascertain what alteration in conductivity took place when the water was rendered air-free. For this end he employed a glass apparatus resembling in construction the so-called "water-hammer." A glass bulb of some 150 c.c. capacity, which served as a retort, was connected by a glass tube with a small glass receiver fitted with platinum electrodes. In this receiver the resistance of the water was measured by the use of a galvanometer and a continuous current, as the latter was so feeble that no appreciable effect was produced by polarisation. The glass connecting-tube was provided with a vertical branch, through which water, or liquids to clean the apparatus, could be introduced. Having admitted a quantity of purified water into the bulb, the vertical tube was then connected with a mercury air-pump, the pump set in action, and the water repeatedly shaken. A flask of cooled sulphuric acid was also put into communication with the evacuated enclosure to absorb water vapour, and thus promote partial distillation of the water. When dissolved gases had been removed, the vertical tube was sealed, and water was then distilled from the bulb into the receiver, the former being immersed in a bath at a temperature of 30° to 40°, and the latter in a cooling mixture at from 0° to − 8°, the temperature being kept as low as possible in order to diminish the solvent action of water on the glass. The value obtained in this way for the conductivity at 18° was 0·25, or a number which is practically only one-third of that given by water distilled in air.

Small as this number was, it was not supposed to represent the actual conductivity of water, because experiment showed that the conductivity altered rapidly with the time, owing to the dissolution by the water of material from the glass receiver, and from the electrodes. The correctness of this supposition is strikingly verified in a communication recently made by Kohlrausch and Heydweiller to the Berlin Academy of Sciences (*Sitzungsberichte*, March 1894). One of the pieces of apparatus used in 1884, and described above, had been allowed to stand filled with water for some ten years, and, apparently from long contact with the water, the glass has become much less soluble than it is under ordinary circumstances. Indeed, during the time necessary for an observation the conductivity does not alter appreciably, and only rises by 0·01 in a day. The method of experiment employed is similar to that just described, the main modifications consisting in additional precautions to obtain the water air-free, and in freezing the purified water prior to its introduction into the apparatus. This method of freezing, suggested first by Nernst, is of value in eliminating volatile impurities which might distil over with the steam. The smallest value now found for the conductivity is ·0404 at 18°, or a number which is only 1/2000th of the original value given by Pouillet, and only one-sixth of that obtained in the same apparatus in 1884.

Since with each improvement the value for the conductivity has been largely reduced, the question which naturally arises in connection with this last result is, how closely can it be supposed to approximate to the truth? Indeed, seeing that the conductivity is so very small, it might fairly be suspected that absolutely pure water is itself a non-conductor, and that the observed conductivity is merely due to the presence of a slight trace of impurity. As it seems almost impossible to answer this question by purely experimental methods, theoretical aids have to be employed, and by means of the hypotheses involved in the new theory of solutions, Kohlrausch and Heydweiller proceed to show that pure water is actually a conductor, and that its conductivity can be ascertained from their observations. The method they employ is briefly as follows:—According to Arrhenius, if water is a conductor, the reason for this is that certain of its molecules exist dissociated into the ions H and OH. Moreover, the magnitude of the conductivity depends upon two factors: firstly, on the number of dissociated molecules; and secondly, on the velocities with which the ions travel. The conductivity varies with the temperature because the number of dissociated molecules, as well as the ionic velocities, increases with the temperature. From these theoretical views, although it is not possible to estimate the actual value of the conductivity, yet the rate at which it should vary with the temperature may be ascertained. For, in the first place, according to van't Hoff, the extent of the dissociation should vary with the temperature just as it does in a dissociating gaseous system; and in the second place, the velocities of the ions H and OH may readily be obtained at different temperatures from measurements on dilute aqueous solutions, such as those of KOH, HCl, and KCl.

Now, Kohlrausch and Heydweiller measured at 18° the temperature-rate of change for a series of samples of water of different degrees of purity, and also the conductivity of two samples of very pure water at temperatures between − 2° and 50°. They then assumed that the observed conductivity was really a sum, being composed of the conductivities of pure water and a dissolved impurity. They were thus enabled to show how it is possible, by making use of the rate of change as deduced by theory for the single temperature of 18°, to obtain from their observations the conductivity of pure water at different temperatures.

The first result arrived at, is that the temperature function of the conductivity over the entire range from − 2° to 50° agrees within the limits of the experimental errors with the function predicted by theory. This, as the authors remark, is one of the most remarkable confirmations yet adduced of the validity of the hypothesis of the new theory of solutions. The second and the most important conclusion for the question under discussion is, that at 18° the conductivity of pure water has in all probability the value 0·0361. The smallest value actually observed, it will be remembered, was 0·0404. The impurity present in the sample affected the conductivity, therefore, by 0·0043, or by some 10 per cent. If this impurity were of the nature of a salt, as in all likelihood it is, the amount which would exert this effect would not require to be more than a few thousandths of a milligram per litre. We have here, therefore, the remarkable result that an impurity of this nature, if present to the extent of only a few parts per thousand million, is capable of influencing the conductivity by as much as 10 per cent. of its value. This, together with what has already been said, leaves little question that of all the physical constants of water, there is none which is so sensitive to small traces of dissolved impurity as its electric conductivity.

J. W. RODGER.

NEO-VITALISM.[1]

A QUARTER of a century ago, du Bois-Reymond headed the revolt of Mechanicalist Biology against the Vitalism of Johannes Müller. From Bichât to Magendie, from Johannes Müller to Schwann, the pendulum swung backwards and forwards; but it was reserved for du Bois-Reymond, in his now famous Berlin addresses, together with Ludwig and Helmholtz, to expose the fallacies of vitalism, and establish physiology on a mechanical basis.

In the present address he takes up arms against the "new vitalism," which since the discoveries of Heidenhain *re* activity of cell in secretion, *versus* mere mechanical diffusion, has made a new departure, based on a partial misconception of these secretory activities. The position of the debate as it now stands will be best shown by an abstract of Prof. du Bois-Reymond's recent manifesto.

From Descartes and Leibnitz, until they encountered their first opponent in Magendie, vitalistic theories were paramount. During this period "vital force" was conceived as the attribute of the soul in distinction to the body, or confused with the so-called "nervous principle," with animal heat or electricity.

Johannes Müller and Schwann again fought out the question; even the discovery by Schwann of independent cell-life in the organism failing to convince Müller that his views were erroneous. The overthrow of vitalism was reserved for Ludwig, whose autographic methods strengthened the physical side of experimental physiology. He came forward as the champion of anti-vitalism, and the same position was taken up by many of Müller's immediate pupils. The fundamental difference between this and all previous criticism lay in the physico-mathematical training of the antagonists, which enabled them to detect the πρῶτον ψεῦδος of vitalism. This prime error is the misconception of "force." Force is not an entity existing apart from matter; it is ultimately a mathematical concept, standing for the physical changes which alone can be known to us. The atoms are not a truck to which the forces can be harnessed; their attributes are eternal, integral, inalienable. Helmholtz said that without a rational conception of nature, scientific research would have no meaning; vital force, however, is unthinkable.

The fundamental distinction between organic and inorganic bodies has not been adequately recognised. In crystals, and dead bodies generally, matter is in static equilibrium, stable, indifferent, or labile; in living organisms, the equilibrium is dynamic. As in heat, and electrical diffusion, the rise and fall of current is balanced; there is constant metabolism. And metabolism, as well as the conservation of energy, present insuperable difficulties to the vitalist. Heat and muscular work, ciliary and amœboid movements, not least electricity, cannot be generated in animals otherwise than by conversion of potential into kinetic energy, by oxidation of carbon and hydrogen. For this nutritive matters—air, warmth, moisture, and for plants light (the "integrating stimuli" of J. Müller) are indispensable

[1] "Ueber Neo-Vitalismus." Von du Bois-Reymond. Sitzungs Berichte der Akademie der Wissenschaften zu Berlin. Oeffentliche Sitzung zur Feier des Leibnizischen Jahrestages vom 28 Juni, 1894.