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.

conditions. And we must further compare the speed of organic processes with those of the crystal—quiescent to all eternity, unless disturbed by external forces. One of the finest conceptions of modern science is that the dynamic equipoise in the life of the individual corresponds to the cycle of living matter in all nature.

Labile equipoise is, however, preponderant in the organism. And here is the simplest explanation of the reaction which Müller held peculiar to living beings—excitability. The specific energies yielded up by living things in response to stimulus, amount to nothing more than the mechanical reaction of stored-up energy which we find, *e.g.*, in a chronometer. A repeating clock, in its specific reaction to stress or strain, heat or cold, moisture or dryness, electrical or chemical influences, presents a close analogy to the living muscle.

A final blow, it seemed, was dealt to vitalism by Darwin's "Origin of Species," which, through natural selection and the survival of the fittest, accounted rationally for existing variations. Thus the controversy was to all appearance ended. Of late, however, on anatomical rather than on physiological grounds, a new school of vitalism has arisen. By a somewhat strained conclusion from the labours of Schwann and Heidenhain, it is asserted that the processes deriving from elemental organisms are too vast in relation to the latter to be accounted for on mechanical principles. A more satisfactory *rationale* for heredity is also demanded.

Prof. du Bois-Reymond dismisses in a few words the arguments of Driesch and Rindfleisch (1888–93). In regard to Bunge ("Lehrbuch der physiol. Chemie," 1887), he points out that the "activity behind which lies the mystery of life" is only static equilibrium of the organism, dependent on integrating stimuli, and reducible to a physical equation. In fact, it is metabolism, maintained by chemical processes, which convert potential into kinetic energy. We have here the πρῶτον ψεῦδος of the older vitalism, for it matters little whether we deal with the comparatively simple problem of fifty years back, or, with Driesch and Bunge, search into the cell and its atoms, or their yet unknown final particles. Impassable, indeed, are the limits of our knowledge, but let us confine our *ignorabimus* to its proper frontier.

To the first contention of Neo-vitalism, du Bois-Reymond opposes the molecular theory with its infinitesimal particles of matter; for the last, he refers us to the current controversy between Weismann and Herbert Spencer. There is, doubtless, room for criticism of the Darwinian theory. For instance, natural selection fails to account for the appearance of organs such as the poison-fangs of snakes or the electric organs of fishes, which are useless in the struggle for existence until fully developed. But if Darwinism were fore-doomed, and exposed, in the words of Herr Driesch, as "a cheap and specious deception," it is improbable that Neo-Vitalism would reap any benefit. There may be still another solution to the problem.

Now, as before, we stand in face of the unsolved riddle, Origin of Being, with all the wondrous chain and intricacies of development. Yet as an alternative to supernaturalism, we can conceive one primordial act of creation whereby the germ of life inherent in matter could develop by its intrinsic laws into the brain of a Newton. Thus, with no day of creation the whole order of nature would evolve mechanically, without intervention of Old or New Vitalism.

And so we return upon the ideas of Leibnitz, save that Materialism replaces Supernaturalism, inasmuch as we may conceive that infinite matter, with its qualities as we know them, has been circling in infinite space from all eternity.

FRANCES A. WELBY.

SCIENCE IN THE MAGAZINES.

PROF. A. W. RÜCKER contributes to the *Fortnightly* a brief sketch of the work of von Helmholtz. Our readers are familiar with the investigations carried out by this eminent physicist; nevertheless, the two concluding paragraphs of Prof. Rücker's article sums up the chief of them so admirably as to be worth quoting here.

"He was one of the first to grasp the principle of the Conservation of Energy. He struck independently, and at a critical moment, a powerful blow in its defence. He penetrated further than any before him into the mystery of the mechanism which connects us with external nature through the eye and the ear. He discovered the fundamental properties of vortex motion in a perfect liquid, which have since not only been applied in the explanation of all sorts of physical phenomena, of ripple marks in the sand, and of cirrus clouds in the air, but have been the bases of some of the most advanced and pregnant speculations as to the constitution of matter and of the luminiferous ether itself.

"These scientific achievements are not, perhaps, of the type which most easily commands general attention. They have not been utilised in theological warfare; they have not revolutionised the daily business of the world. It will, however, be universally admitted that such tests do not supply a real measure of the greatness of a student of nature. That must finally be appraised by his power of detecting beneath the complication of things as they seem, something of the order which rules things as they are. Judged by this standard, few names will take a higher place than that of Hermann von Helmholtz."

In the same magazine Sir Robert Ball discusses the possibility of life in other worlds—a subject that has a curious fascination for the unscientific, but upon which the author throws the light of modern scientific knowledge. "No reasonable person will," he thinks, "doubt that the tendency of modern research has been in favour of the supposition that there may be life on some of the other globes. But the character of each organism has to be fitted so exactly to its environment that it seems in the highest degree unlikely that any organism we know here could live on any other globe elsewhere. We cannot conjecture what the organism must be which would be adapted for residence in Venus or Mars, nor does any line of research at present known to us hold out the hope of more definite knowledge." The verdict thus appears to be "possible, but not probable," and the subject therefore stands where it did.

Mr. R. S. Gundry contributes to the same magazine an article on Corea, China, and Japan; and Mr. A. H. Savage-Landor one on Japanese people and customs; while Mr. G. Lindsay describes his rambles in Norsk Finmarken.

Prof. N. S. Shaler contributes to *Scribner* an interesting paper on "The Horse," the text being illustrated with pictures by Delort. He does not speak very highly of the animal's intelligence. In his words: "The mental peculiarities of the horse are much less characteristic than its physical. It is, indeed, the common opinion, among those who do not know the animal well, that it is endowed with much sagacity, but no experienced and careful observer is likely to maintain this opinion. All such students find the intelligence of the horse to be very limited. Although some part of this mental defect in the horse, causing its actions to be widely contrasted with those of the dog, may be due to a lack of deliberate training and to breeding with reference to intellectual accomplishment, we see by comparing the creature with the elephant, which practically has never been bred in captivity, that the equine mind is, from the point of view of rationality, very feeble." It is worth remark, however, that a good deal of misapprehension exists as to the intelligence of the elephant. According to the best authorities, though elephants are docile and obedient, their intellectual capacity is below that of most other Ungulates. Colonel H. G. Prout contributes his second article on "English Railroad Methods," giving a number of interesting facts respecting passenger and freight traffic, cost of construction, &c., in England and America.

Colonel A. G. Durand shows, in a paper in the *Contemporary*, that the southern region of the Eastern Hindu Kush is one full of interest. In the *Humanitarian*, St. George Mivart writes on "Heredity." A portrait of the author forms the frontispiece of the number Mr. Grant Allen continues his moorland idylls in the *English Illustrated*, his subject this month being house-martins.

Chambers's Journal contains its usual complement of chatty articles, among which may be mentioned "Feathered Architects," "The Infinity of Space," and "The Vanishing Eland," *Longman's Magazine* reprints an address, "How to Make the Most of Life," delivered by Sir B. W. Richardson before the Literary and Scientific Section of the Grindelwald Conference this year. The Rev. B. G. Johns writes on "The Injuries and Benefits of Insects" in the *Sunday Magazine*, and the Rev. T. R. R. Stebbing contributes an instructive article on certain crustacea to *Good Words*. The latter magazine also contains an article on tea, by Mrs. A. H. Green, and a well-written explanation of the laws of motion, by Emma Marie Caillard.