CURRENT SCIENCE—50 YEARS AGO

SUPPLEMENT TO "CURRENT SCIENCE".

The British Association for the Advancement of Science, Aberdeen, 1934*.
Presidential Address—The New World-Picture of Modern Physics, By Sir James Jeans.

Sir James Jeans delivered a highly thought-provoking address at the Aberdeen Meeting of the British Association for the Advancement of Science, taking as his theme "The New World-Picture of Modern Physics". He first commented on the happy auspices under which they had assembled, the Scottish meetings having been traditionally successful, but there was the early death of Sir William Hardy which he deplored and which he said had cast a shadow in all their minds. After paying an eloquent tribute to the excellent qualities of the departed, the lecturer proceeded to the subject of his address. In the fifty years' interval between the time when one theoretical physicist—Lord Rayleigh—had occupied the chair and the present occasion when again the presidentship had fallen to a theoretical physicist, the science of physics had changed and developed beyond recognition. The old explanations, based on an attempt to understand nature by means of familiar models, had failed to cover the new facts and the mathematical formulae which represented the facts well showed that the explanation was like a parable. The modern difficulties regarding the nature of the world were all due to the mistake of taking these parables to represent the actual truth. It is a natural tendency for man to prefer concrete facts to abstract principles, but since all measurement implies the comparison of one quantity with another of similar nature, we could become cognizant only of the relations which we ourselves discoverd, but the essential nature of the quantity compared would be beyond comprehension. Thus all our knowledge about observables would be numerical or mathematical in content while whatever we thought we knew about unobservables would be pure assumption. That was the reason why the attempts of the nineteenth century physicists to explain the wave-nature of light by trying to picture the properties of the ether led to false conclusions. It was only the imagery that led people to expect a positive result in the Michelson-Morley experiment. The null-result showed the error of taking this imagery to be representative of external nature. Since the general theory of relativity showed that the space-time continuum could be twisted and warped as much as we please, even this continuum could not be itself part of Nature. Since all our knowledge comes, through our senses it was but natural to postulate the existence of "matter" as a starting point for the effects which reached our senses, but this "matter" is as unobservable as the ether. For example, earthquake waves affect our houses by travelling along the surface of the ground but it is not right to assume that they originate in the surface. So also space and time or the space-time continuum might be the means through which our senses are affected but that would not prove that they were part of Nature.

Theoretical physics is no longer concerned to study the Newtonian Universe which it once believed to exist in its own right in space and time. It merely sets before itself the modest task of reducing to law and order the impressions that the universe makes on our senses. Its task resembles that of the map-maker who can represent different aspects of a region of the earth's surface by means of different projections, but who does not make the mistake of taking the map to be the earth. Newtonian physics was like the map of a small region in that it represented the motions of medium-sized objects correctly but failed to represent the infinitely great and the infinitely small. The new physics provided a map of the whole universe but some properties of the small map, such as representation in time and space and the old determinism, could no longer be found in the larger one. Just as the map-maker requires different kinds of maps to represent different aspects of the earth, theoretical physics provides two pictures—the particle picture and the wave picture. Bohr's theory of the hydrogen atom showed that the particle picture was inconsistent with Newtonian determinism - there was no way of predicting which particular atom would suddenly change in energy and radiate, as Finstein pointed out. But even this picture failed to represent the whole of

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experience. Then came the wave picture; this gives a wave in ordinary space only for a crowd of electrons moving as in an electric current, but the picture extends to more dimensions when other phenomena have to be represented. It has not been possible to combine the particle and the wave picture into one better representation as we can combine the different kinds of maps into a single globe. We cannot say whether it is impossible to arrive at such a unified picture or it is some ingrained habit of thought that is preventing us from realising it.

In spite of this lack of a unified representation of the Universe, the relation between the particle and the wave picture is definitely known. The more stormy the waves at any point in the wave picture the more likely we are to find a particle at that point in the particle picture. Yet if the particles existed as points and the waves depicted the chances of their existing at different points of space—as Maxwell's law does for the molecules of a gas—then the gas would emit a continuous spectrum instead of the line spectrum that is actually observed. Thus we had better put our statement in the form that the electron is not a point-particle, but that if we insist on picturing it as such, then the waves indicate the relative proprieties of picturing it as existing at the different points of space. But propriety relative to what? The answer is—relative to our own knowledge. If we know nothing about an electron except that it exists, all places are equally likely for it, so that its waves are uniformly spread throughout the whole of space. By experiment after experimdnt we can restrict the extent of its waves, but we can never reduce them to a point or indeed below a certain minimum; the coarse-grainedness of our probes prevents that. There is always a finite region of waves left. And the waves which are left depict our knowledge precisely and exactly; we may say that they are waves of knowledge—or perhaps even better still waves of imperfections of knowledge—of the position of the electron.

But there is one surprising situation here; the waves are supposed not to be a picture of our knowledge of Nature, but of Nature itself. That would mean that Nature was in our minds and not external to the observer. The Nature we study is not the object of our perceptions but is made up of those perceptions themselves. We are forced to this conclusion because whenever the particle picture comes into conflict with the wave picture the wave-picture has been shown by observation to be the correct one. Such is the case in G. P. Thomson's experiments on the diffraction of electrons, or in the phenomena of the leakage of particles through a potential barrier. When we retain the particld picture and try to explain what peculiarity allows some out of a number of similar particles to get through the barrier, we will have to answer that it is a question of chance or Fate. For example, when we picture light as a swarm of photons, it is difficult to see why a certain number of them pass through a semi-transparent obstacle, and which individual photons are thus singled out. Thus the behaviour of any individual photon—whether it will be reflected or transmitted—is indeterminate. But in the wave picture the question of the individual photon does not arise at all and hence the process is quite deterministic. Similarly, the principle of Pauli shows that an electric current should not be thought of as a swarm of identifiable electric particles. If two electrons collide and go off in two different directions we have no right to say that the latter electrons are the same as those that collided. The determinism which appears in the new physics is one of waves and so, in the last resort, of knowledge. Where we are not ourselves concerned we can say that event follows event; where we are concerned, only that knowledge follows knowledge. And even this knowledge is one only of probabilities and not of certainties. So it is impossible to decide whether our minds can change what is happening in reality or whether they only make it look different. The problem of free-will will hence remain a debatable question which cannot receive a definite answer. We cannot say that materialism is dead, but it has to be so refined that it may be doubted whether it may still be called materialism. The objective and material universe of the Victorian scientist is shown to consist of little more than constructs of our own minds. But the problem arises—why should all our minds construct the same nature? Sir James Jeans answers that it is probably because all our minds are parts of one whole, our individualism being merged in the stream of life when we cease to view ourselves in space and time.

Sir James then proceeded to show how the complaint that all our modern woes of unemployment and competition were due to the indiscriminate advance of science was not entirely well founded. He pointed out that the tragedy lay not in man's control over Nature but in the absence of moral control over himself. The remedy lies not in giving up science, but in extending its methods to other walks of life, by means of the science of psychology for instance. If economic depression and unemployment arise from rationalisation and scientific efficiency, science also provides new avenues of employment by creating new industries. It is certainly safer to solve the problem this way than to

scrap science and sit patiently waiting for the catastrophe due to increase of population to come to us in the form of war, famine and disease. Nor is it right to decry pure science, for no investigator knows beforehand what discovery he is going to make and in what way it can be applied. If pure science is stifled, applied science will be nipped in the bud. So Sir James concludes by exhorting all thinking men and women to ponder and decide whether it is better to risk the fate of that over-ambitious scientist Icarus, rather than resign ourselves without an effort to the fate which has befallen the bees and ants.

NEWS

CREAM, SUGAR, AND CHOLESTEROL

. . . "Coffee intake from three-day diet records was studied in association with plasma lipo-protein concentrations in a cross-sectional sample of 77 middle-aged American men to determine the significance and form of their interrelationships. The number of cups consumed per day correlated positively with levels of apolipoprotein B . . . and became more strongly correlated when adjusted for age, cigarette use, adiposity [amount of fat], aerobic capacity, nutrient intake, and stress. Coffee intake also correlated with total cholesterol and low-density lipoprotein (LDL) cholesterol levels when adjusted for these confounding factors. Graphic analyses revealed that plasma concentrations of apolipoprotein B and LDL-cholesterol were unrelated to intake of up to two cups of coffee per day and positively associated with intake exceeding two to three cups. These results suggest that male heavy coffee drinkers have lipoprotein profiles suggestive of increased cardiovascular disease risk, although the causality remains to be determined."

[(Paul T. Williams (Stanford U. Sch. of Medicine) et al. in *JAMA—Journal of the American Medical Association* 253(10): 1407-11, 8 Mar 85). Reproduced with permission from Press Digest, *Current Contents*®, No. 19, May 13, 1985, p. 16, (Published by the Institute for Scientific Information®, Philadelphia, PA, USA.)]

CAN POLIO BE ELIMINATED?

. . . "It must be realized that paralytic poliomyelitis can never be completely eliminated by the use of poliovirus vaccines because there is adequate proof that clinically and pathologically typical paralytic poliomyelitis caused by some other enteroviruses has occurred sporadically and occasionally also in small epidermics. [However], studies on the immunogenic activity of synthetic peptides may greatly illuminate our understanding of the antigenic components involved in short-term protection against various infectious agents responsible for human disease. I hope they may also lead to an understanding of how most natural viral infections produce lifelong persistence of neutralizing antibodies and immunity without reinfection. The fascinating, highly sophisticated studies on the nucleotide sequences of the three types of the most highly attenuated and most highly paralytogenic strains of polioviruses, it is hoped, coupled with equally sophisticated future studies on the phenotypic expression of the quantitative differences in the many distinct genetic properties of polioviruses may provide the knowledge with which to construct deletion mutants . . . . "

[(Albert B. Sabin (Natl. Insts. of Health) in *Journal of Infectious Diseases* 151(3): 420-36, Mar 85). Reproduced with permission from Press Digest, *Current Contents*®, No. 19, May 13, 1985, p. 16, (Published by the Institute for Scientific Information®, Philadelphia, PA, USA.)]