good agreement with the statements of our theory of the microstructure. In many cases, it is true, the experiments[10] of the transition phenomena seem yet to be obscured by hysteresis and other retardation effects, which prevent the realization of thermal equilibrium and render difficult the theoretical discussion. The theory can also account qualitatively for these disturbing effects[11], though there still remains something to be done. But for a reasonable discussion of these questions we would have to occupy ourselves with much more detail than could be given here.

The macroscopic theory we have discussed shows that it is possible to interpret the phenomena in a way which avoids the paradoxes that seemed hitherto to render impossible any theory of supraconductivity. The new interpretation includes, moreover, a very simple description of the phenomenon in the language of wave kinematics. The next stage will have to be the development of the electronic basis of this theory. One might presume that the new aspect here presented of supraconductivity may also give an indication for the construction of a molecular model of the supraconductor[12].

[6] The following interpretation seems first to have been given by Gorter, C. J., NATURE, **132**, 931 (1933). Gorter, C. J., and Casimir, H., *Physica*, 1, 305 (1934).

[7] London, F., *Physica*, **3**, 450 (1936); NATURE, **137**, 991 (1936).

[8] The magnetostatic part of this theory has also been developed by Peierls, R., *Proc. Roy. Soc.*, A, **155**, 613 (1936), quite independently of our conceptions, as a pure phenomenological description of a new 'intermediate' state, different from both the pure supraconductive and the normal state. But it can be shown[7] that, thermodynamically speaking, the intermediate state has not to be considered as a further independent phase but as a *mixture* of the two phases.

[9] De Haas, W. J., and Guinau, A., *Physica*, **3**, 182, 534 (1936). Mendelssohn, K., *Proc. Roy. Soc.*, A, **155**, 558 (1936). Shoenberg, D., *Proc. Roy. Soc.*, A, **155**, 712 (1936).

[10] For example, De Haas, W. J., and Casimir-Jonker, M. J., *Physica*, **1**, 291 (1934).

[11] London, H., *Proc. Roy. Soc.*, A, **152**, 650 (1935). Keesom, W. H., and Van Laer, P. H., *Physica*, **4**, 499 (1937). Grayson Smith, H., *Trans. Roy. Soc. Canada*, **31**, 31 (1937). De Haas, W. J., Engelkes, A. D., and Guinau, O. A., *Physica*, **4**, 595 (1937).

[12] (Added in the proofs). In a paper just published (*Phys. Rev.*, **52**, 214 (1937), J. C. Slater has tried to sketch such a molecular model for our theory. See also Slater, J. C., *Phys. Rev.*, **51**, 195 (1937), and London, F., *Phys. Rev.*, **51**, 678 (1937).

Bicentenary of the Birth of Galvani

Celebration at Bologna

THE great contribution of Luigi Galvani to the advancement of the sciences of electricity and electro-physiology has been fittingly celebrated by a scientific congress held on October 17–20 at the invitation of the City and University of Bologna, the historic centre of learning where Galvani worked.

Galvani was born on September 9, 1737. In his early years it is recorded that he wished to enter the Church, but that on the insistence of his family he took to the study of medicine, and at twenty-five years of age had become lecturer in anatomy in the University of Bologna. Here his work lay in the field of anatomy and physiology until his great electro-physiological discovery made in 1791. It has been stated that the discovery arose from an observation that when animals were suspended on iron railings by copper hooks, a twitching of the muscles resulted. His published work states, however, that he observed the twitchings in the dissected muscles of a frog's leg whenever a spark was passed from a neighbouring electric machine to some other object, the only condition being that the animal should be in contact with some metal or other good conducting substance. A further experiment showed that the same convulsions could be obtained by the "sole application of some conducting arc", of which one extremity touched the muscles and the other the nerves or spine of the frog. The motion was believed by Galvani to result from a union of the negative charge of the muscle with the positive electricity proceeding along the nerve.

The discovery attracted the attention of Volta, working in Como, who thereupon made an extensive series of experiments. He showed in particular that convulsions could be excited in the legs or other members of the animals by "metallic touching either of two parts of a nerve only or of two muscles" provided only that an arc consisting of two metals was employed. He ascribed the effects seen to the electricity produced by the contact of dissimilar metals, and showed also that the electric current acted not on the muscles directly but through the medium of the nerves. These results, which were communicated to the Royal Society in 1793 by his countryman Cavallo, led directly to his construction in 1800 of the voltaic pile.

At the opening session of the recent Congress, attended by the King and Queen of Italy and members of the Government, Prof. Q. Marjorana delivered a commemorative address on the life and work of Galvani. Later in the day the delegates were invited to a formal opening of a library and collection of records of Galvani. For these sessions, Bologna made public holiday. The streets were lined with troops; girls from the villages paraded in traditional costume, the Balilla were out in force, and the sober black of the party uniform contrasted vividly with the splendour of historic costumes and academic robes. We cannot, it seems, compare with the totalitarian States in our devotion to men of science of the past.

The scientific work of the Congress was divided as was fitting into sections dealing with physics, experimental biology and radiobiology. At the plenary session, addresses were delivered by Prof. Niels Bohr on biology and atomic physics, by Prof. E. D. Adrian on the electrophysiology of the sense organs and by Prof. A. Gunsett on radiobiology and radiotherapy.

Prof. Bohr discussed the bearing on biological problems of the latest developments of atomic theory. In particular he discussed how far the limitation of the classical idea of causality resulting from the "Principle of Uncertainty" could serve to harmonize the mechanistic and vitalistic views of biological processes. He pointed out that the absorption of only a few light quanta or perhaps one light quantum is sufficient to produce a retinal impression, and that the limitation to the efficiency of the eye is almost certainly imposed by the atomic nature of the light quantum. It seems probable also that other organs have similar limits. Furthermore, it appears that the regularities peculiar to atomic processes which are foreign to causal mechanics are at least as important for the understanding of the behaviour of living organisms. Atomistic features are therefore of essential importance in biological processes.

The recognition of this importance is not, however, sufficient for a comprehensive explanation of biological processes, and it becomes necessary to examine the position of the vitalists, that a peculiar force unknown to physics governs all organic life. Prof. Bohr believes, however, with Newton that the foundation of science is the belief that Nature under the same conditions will always exhibit the same regularities. If, therefore, the analysis of the mechanism of living organisms could be probed as far as that of atomic phenomena, one would scarcely expect to find any features differing from the properties of inorganic matter.

It is necessary to remember, Prof. Bohr continued, that biological experiments differ from physical experiments in the necessity for keeping the organism alive, and that this restriction imposes uncertainties as to the physical conditions to which they are subjected. It might well be that this uncertainty is just sufficient to allow the organism to conceal from us the secrets which are connected with life, just as in physical experiments the disturbance produced by observation often prevents a strictly causal description of the phenomena. Great caution should, however, be exercised in such considerations, and he considered that quite unwarranted applications of the "Principle of Uncertainty" have been made by many writers.

Prof. E. Fermi gave an account of the beautiful experiments carried out by his school in Rome on the properties of neutrons and on the important information obtained on the position and life of excited states of nuclei. He described experiments which show that fast neutrons lose the greater part of their energy on scattering by heavy nuclei such as lead.

Prof. G. v. Hevesy gave an account of his work on the use of radioactive phosphorus as an indicator in biological processes. Radiophosphorus, which can be produced in large quantities by a transmutation process, emits electrons and decays with a convenient period of 14 days. By adding radiophosphorus to the food of animals, the path of the phosphorus atoms can be traced through the different stages of the metabolic process. Thus the greatest part of the phosphorus enters the blood stream, and after a few minutes the bulk of the phosphorus atoms present in the blood in the phosphate stage will exchange places, principally with those present in the skeleton but also with those present in the muscles and other organs. At an appreciably slower rate proceeds the synthesis of the numerous organic phosphorus compounds present in the organism.

Prof. P. Debye described new experiments on the dielectric loss in liquids, using undamped electric waves having a wave-length of the order of a centimetre. The experiments show that molecular rotation does not play a great part in the dielectric loss, probably owing to the rotation being prevented by the quasi-crystalline structure of the liquid. The loss seems rather to result from relative motion of the component units of the molecule.

Prof. W. Bothe gave two new examples of the existence of radioactive isomers—atomic nuclei having the same charge and mass but having different decay constants. Thus ^{80}Br can be produced either by adding a neutron to ^{79}Br or by detaching a neutron from ^{81}Br. In both cases two radioactive products are produced having half-lives of 18 min. and 4·2 hours. He gave also new information on the resonance energies of light nuclei, showing that the same resonant states can be produced by different types of transmutations.

Prof. W. Heisenberg discussed the mechanism of shower production by cosmic rays. He differentiated between two processes. In the cascade process, showers are built up from the successive conversion of electron energy into radiation, radiation into pair production and then further loss of electron energy to radiation. This process, described theoretically by the theories of Oppenheimer and Coulson, Bhabha and Heitler seems to be confirmed by Wilson chamber photographs of Street and Stevenson showing the 'build up' of the shower. A second process results from the conversion of the energy of a heavy particle into positive and negative electrons through the intermediary of proton-neutron transitions. Experimental results on cosmic rays were discussed by Prof. B. Rossi.

Dr. F. W. Aston gave an account of his recent measurement on the masses of nuclei by the method of close doublets, and Prof. M. L. E. Oliphant and Dr. J. D. Cockcroft described other recent work of the Cavendish and Mond Laboratories, Cambridge, including a description of the new High-Voltage Laboratory and its equipment and the recently reported peculiar properties of liquid helium.

In all, about twenty physical papers were communicated to the Congress.

Obituary Notices

Mr. W. S. Gosset: "Student"

WILLIAM SEALY GOSSET, who died after a short illness on October 16, was best known to statisticians throughout the world by his pseudonym "Student", under which his scientific contributions were published. He was born on June 13, 1876, and became in turn a scholar at Winchester and at New College, Oxford, where he worked at mathematics and chemistry. In 1899 he joined the firm of Arthur Guinness, Son and Company, and a few weeks before his death had been appointed head brewer; his handling of statistics was only one of many duties.

Gosset's work brought him at an early stage against the problem of interpreting routine tests in chemical analysis, and at the suggestion of one of his chiefs he turned his mind to the question of what help the theory of probability could bring to the practice of brewing. He first met Karl Pearson in the summer of 1905, and a year later went to London to spend some months in the Biometric Laboratory at University College. Throughout his life he was to gain much from the continuation of this contact between 'student' and 'professor', but from the very beginning he launched out on research lines of his own which were to prove of very great importance to the development both of the theory and practice of mathematical statistics.

Under Galton, Weldon and Pearson, the Biometric School had been mainly concerned with the handling of comparatively large samples from biological populations, but Gosset in his daily work was forced to attempt to draw conclusions, leading to executive action, from the analysis of relatively small numbers of observations. Thus he might need to answer such a question as, "What is the accuracy of this arithmetic mean based on 8 observations (the population standard deviation being unknown)?" Thirty years ago a statistician was forced to reply somewhat as follows: "Following the method appropriate for large samples the odds are 19 to 1 that your unknown population mean lies between (say) 22·1 and 24·6, but as the sample is so small this statement is entirely unreliable." Gosset's work has, however, made possible a far more useful answer, namely, "If you have taken reasonable precautions to see that your sample is randomly selected, the odds are 19 to 1 that the limits 21·8 to 24·9 include the unknown population mean." At the expense of somewhat broadening limits which before had little meaning, definite information has replaced a counsel of despair. This process of making full allowance within the statistical test itself for uncertainty regarding the standard deviation due to small numbers, by use of what in fact are ratios instead of absolute measures, has sometimes been termed 'studentizing'; the conception involved has been the basis of a rapid theoretical advance without which many of the problems of agriculture and industry could scarcely have been brought within the range of statistical inquiry.

But Gosset's contribution was only in part a theoretical one; he recognized the risks involved in basing action on the application of statistical calculus to few observations, yet all his work as a practical statistician in industry went to show that, with due precaution, these risks could be taken with economic advantage. Thus all that he wrote, whether on the reliability of the mean and standard deviation, on methods of measuring correlation, on the problem of counting cells with a hæmocytometer or on the checking of routine analysis, helped to give confidence to those who were trying to apply similar methods in the face of scepticism or even opposition.

Besides dealing with questions which concerned the chemist and biologist, Gosset's work led him into the field of agricultural experimentation. His paper of 1923 "On Testing Varieties of Cereals" was one of the most important early contributions to an era which has been notable for the introduction of precise statistical methods into agricultural research. His influence spread very widely in later years, not only through the medium of his written papers, but also through a correspondence which linked him to experimenters all the world over. He was always ready with advice and friendly criticism, and many must have gained from his suggestive mind the initial ideas which have borne fruit in their later research.

Much could be written, if space allowed, of the charm of Gosset's personality, with its modesty, unconventionality and tolerance. It is to be hoped that it will be possible to do fuller justice elsewhere to a man who has occupied a very special place in the hearts of so many friends in Great Britain and abroad.

E. S. P.