SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS *

Logic and Probability in Physics

AFTER paying a short tribute to the memory of Lord Rutherford, the president of Section A (Mathematical and Physical Sciences), Prof. C. G. Darwin, comes to his main subject, which is the inadequacy of the reasoning processes which have in the past been regarded as the proper machinery of scientific thought. We have set up as the ideal form of reasoning the formal logic of Aristotle; we rarely conform to this ideal, but instead we make use of arguments having no accurate axiomatic basis, which compel belief because of some large accumulation of favourable evidence. The old logic was devised for a world that was thought to have hard outlines, and now that we know that the outlines are not hard the method of reasoning must be changed. The key to the modification lies in probability, but whereas in the past it was expected that probability could somehow be fitted into the old logic, the attempt has always failed, and we must recognize it as an independent principle. Our instincts only accept this with difficulty, but a similar unsatisfying state of affairs used to exist in mechanics, which has been overcome by the quantum theory, and an analogy may be developed between the two cases.

There follows a review of the history of the quantum theory, touching on a number of points of interest, but having special reference to the way in which it has dealt with causality. The old mechanics seemed to point with all the compulsive force of a logical syllogism to absolute determinism. We are still scarcely free from the feeling of this compulsion, but we know it is wrong, and we know where the fault lay. An analogy may be made between this state of affairs and our feeling about the place of probability in logic. We used to feel that classical mechanics provided no room for anything outside itself, and we feel that the old logic is the only really admissible form of reasoning. Certain things refused to fit into the classical scheme and led to the old quantum theory, and we have found that the old logic is inadequate without the supplementary principle of probability. In mechanics the union is completed by the new quantum theory, but we have not yet satisfactorily blended our reasoning principles.

The sort of way the union may come about is suggested by another branch of physical theory, the kinetic theory of gases. One of the most important ideas in the statistical theory of matter has been Gibbs's ensemble. With the old mechanics the ensemble was a rather strange idea, and it was hard to see where it came from, but now it fits beautifully into the new mechanics, for any actual piece of gas is not merely a single member from among the countless representatives in the ensemble, but is itself the whole ensemble. This example suggests a real synthesis of probability with our other reasoning processes, and gives the hope of a true reasoning adapted not to the artificially simplified world of hard outlines of the classical mechanics, but to the real world with its slightly indefinite outlines.

The address concludes with a plea for a reform of our education at both school and university, so that probability and statistics should be given a proper share in our mathematical courses. At present all the attention is given to things susceptible of exact proof, and none to the things of much more frequent occurrence where inaccuracies, tolerances or fluctuations are also of interest. It is not so much that new special courses are needed as that the emphasis should be altered in the ordinary courses of mechanics and kindred subjects. The mathematics would not be any more difficult than in the customary courses, but the train of thought is at present unfamiliar, and it would not be hard to remove this unfamiliarity. In this way the student would acquire a much juster appreciation of the physical world than can ever be acquired by an exclusive attention to those things which are capable of exact proof.

* Lord Rayleigh's presidential address, and the addresses of the sectional presidents, are being published as "The Advancement of Science, 1938". (Cambridge: B.A. Reception Room. London: Burlington House.) 3*s*. 6*d*.

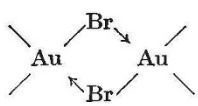
Recent Investigations in the Chemistry of Gold

THE recent advances in our knowledge of the chemistry of gold have for the most part been due to investigations carried out by workers in Great Britain; amongst others, H. Bassett, E. G. Cox, F. G. Mann, Sir Gilbert Morgan, Sir William Pope, W. Wardlaw, and their respective co-workers. This work, together with that of the president of Section B (Chemistry), Prof. C. S. Gibson, and his collaborators, which forms the topic of Prof. Gibson's presidential address, has emphasized the similarities and also the striking anomalies existing among the currency metals, copper, silver and gold, the metals of Sub-group 1 *B* of the Periodic

Classification. These anomalies are unexplained but are, to some extent, correlated with those existing among the transitional metals.

Copper, silver and gold all exist in the univalent condition, but in this state only silver is, from a chemical point of view, a typical metal, since cuprous copper and aurous gold do not form normal salts. In their compounds, cuprous copper and aurous gold are always co-ordinated, but whereas cuprous copper may be 2- and 4-covalent, aurous gold is always 2-covalent, and no compounds are known in which it has a higher co-ordination number. Argentous silver may be 2- and 4-covalent; its co-ordination compounds are almost completely analogous with the corresponding cuprous compounds, and the four valencies of cuprous copper and argentous silver have a tetrahedral configuration. Unlike cupric copper, bivalent or argentic silver is chemically not a typical metal, since it only forms co-ordinated complexes which may be present in electrolytes and non-electrolytes. When it is 4-covalent, argentic silver forms compounds which are analogous and isomorphous with the corresponding cupric compounds, and the four valencies of cupric copper and argentic silver have a planar configuration. One striking anomaly among these metals is the non-existence of bivalent gold. In the tervalent or auric condition, gold again is chemically not a typical metal and is always 4-covalent. Consequently, unlike copper and silver, gold never assumes the 'effective atomic number' (Sidgwick) of the next inert gas. X-ray crystallographic examination has demonstrated the planar configuration of the four valencies of tervalent gold and the linear configuration of the two valencies of univalent gold.

What may be described as the new chemistry of gold has arisen from the study of the organic derivatives of the metal, which were discovered by Sir William Pope and C. S. Gibson in 1907, and their investigation has been extended by Gibson and his collaborators during the last seven years. The organic compounds of gold most readily accessible are colourless crystalline non-electrolytes having the general formula $(R_2AuX)_2$, R and X representing univalent hydrocarbon radicals and halogen atoms respectively. As shown by the low dipole moment and X-ray crystallographic examination, the molecule contains the planar ring structure



which is present in many auric and mixed auric-aurous compounds.

From the bromine derivatives are easily prepared deep red crystalline non-electrolytes having the general formula $(RAuBr_2)_2$. These compounds have high dipole moments and contain the same planar heterocyclic ring containing two 4-covalent auric atoms to one of which two hydrocarbon radicals are attached. In agreement with their constitution, these compounds behave chemically as equimolecular mixtures of the compounds $(R_2AuBr)_2$ and of gold tribromide, $(AuB_3)_2$, the latter compound having the same planar heterocyclic ring mentioned above.

The remarkable tendency, due to co-ordination, for auric and, to a less extent, aurous gold to become members of heterocyclic ring systems is further illustrated by the interesting colourless non-electrolyte, diethylgoldacetylacetone and also by the cyano derivatives obtained by the action of silver cyanide on the first-mentioned compounds. These cyano compounds are non-electrolytes having the general formula $(R_2AuCN)_4$, and the molecule, as shown by the low dipole moment and X-ray crystallographic investigation (H. M. Powell and R. F. Phillips), contains a planar twelve-atom ring having four symmetrically situated 4-covalent auric atoms. These compounds have the additional interest in that, spontaneously or on gentle heating, they yield free hydrocarbon radicals. The first stage of this decomposition yields a mixed 4-covalent auric and 2-covalent aurous compound, $(RAuCN)_4$, the molecule of which again has a twelve-atom planar ring structure containing two symmetrically placed auric and two symmetrically placed aurous atoms, the latter being 2-covalent.

There being no evidence that gold can have higher covalencies than two when it is aurous and four when it is auric precludes the possibility of obtaining optically active gold compounds in which the gold atom is the centre of asymmetry.

Development and Evolution

THE Theory of Recapitulation, which at the opening of this century tended to dominate biological and palæontological thought upon the relationship of development to evolution, has in these latter days fallen into disrepute. This state of affairs is reflected in recent literature by a diversity of views, ranging from complete rejection of the theory to almost unqualified acceptance. Prof. H. H. Swinnerton, in his presidential address to Section C (Geology) seeks, by reference to palæontological evidence, to elucidate the causes of this wide diversity of opinion and to harmonize the observations out of which it has arisen.

In so far as developmental changes reflect evolutionary changes of the past, or foreshadow those which are to come, the relationship of