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SCIENCE AND INDUSTRY IN INDIA[1]

By the late Lord RUTHERFORD OF NELSON

DURING the past fifty years, the British Association for the Advancement of Science has been invited on many occasions to hold its meetings overseas. Four times it has journeyed to Canada (Montreal, 1884; Toronto, 1897; Winnipeg, 1909; Toronto, 1924), twice to South Africa (1905, 1929), once to Australia (1914). This policy of the association of arranging occasional meetings in our dominions has proved an unqualified success. These overseas visits have had a marked influence on the progress of science throughout our commonwealth and by personal contacts have helped much to promote mutual understanding and cooperation between our peoples.

The visit of a representative group of scientific men to our most distant dominions in 1914, in itself an outstanding event in the history of the association, was rendered even more notable by the dramatic circumstances under which the meetings were held, for the arrival of the party in Australia coincided with the news of the outbreak of the great war. Any one who like myself took part in the meetings in Australia and New Zealand in those troubled but stirring times can ever forget the warmth of our reception. We were privileged to witness that wonderful response of the peoples of these lands to the call of danger—a response which we know grew ever greater with the need.

It has long been the wish of the British Association to hold a meeting in India, and difficulties of time and climate alone have stood in the way of its realization. It has been found most convenient for the overseas

[1] Presidential address before the Indian Science Congress Association, prepared by Lord Rutherford before his death and presented to the congress meeting in Calcutta on January 3. This is the first part of the address which contains two other sections, one on Industrial Research in Great Britain and one on Transmutation of Matter.

the film is so thin that convection does not occur, thus allowing both rate and equilibrium to be measured. Virus of foot-and-mouth disease is measured after three minutes. An antibody required only 30 minutes for sedimentation equilibrium. It is necessarily assumed that the agar jelly is of such concentration that it neither swells nor sediments. This, however, can be verified by direct experiment and adjusting the concentration of agar to the requisite value. Any influence of the agar on the absolute rate has to be tested by comparison in some other ultracentrifuge. Sedimentation equilibrium is of course unaffected.

The third method is to prevent convection by simple mechanical design. It is most general because the solution is uncontaminated in any way, and it is equally good for aqueous and non-aqueous systems. It also ranges equally well from the smallest molecules to the largest particles. Elford[10] described such a method for comparatively large particles such as phage or virus, avoiding convection by using an inverted glass, silica or metal tube, 1, 2 or 3 mm in internal diameter, immersed in a commercial or Henriot and Huguenard centrifuge. The particles settle within the tube with an undisturbed boundary, and before this reaches the outer opening of the tube the contents are analyzed. The position of the boundary may sometimes be followed by eye, using scattered or fluorescent light, and the results are fairly accurate. Many parallel holes in one block may be used to give larger volumes.

The author with Alvarez-Tostado has developed completely general methods for the quantitative study of sedimentation equilibrium and of sedimentation rate in mono-disperse or poly-disperse systems of any sort. The sedimentation equilibrium of sucrose[8] gave a molecular weight of 341 in exact agreement with the theoretical value, 342. The essential feature of these extremely simple air-driven ultracentrifuges is the use of a pile or piles of very thin plane horizontal annular rings or washers, with or without spacing pieces, to immobilize the whole or a part of the solution. For sedimentation equilibrium of any mono-disperse system, one pile is sufficient. For rate or for poly-disperse systems a number of concentric piles of these loose washers, each set held together by vertical pins fastened only to the top and bottom of the pile, are placed in the rotor so that after stopping the rotor each set can be lifted out and the contents analyzed to determine rate, equilibrium, true density and number of particle sizes. Another method which we had previously developed was to use piles of sectorial baffles built up horizontally like brick work, in the simplest one-piece metal rotor, obtaining successive portions of the liquid from between them by displacement with a heavier liquid put through a distributing plate while the rotor is running.

[10] W. J. Elford, *Brit. Jour. Exp. Path.*, 17: 399, 1936; Elford and C. H. Andrewes, *ibid.*, 422; Elford and I. A. Galloway, *ibid.*, 18: 155, 1937; F. F. Tang, Elford and Galloway, *ibid.*, 269.

Lastly, Tiselius, Pedersen and Svedberg[11] have now put a partition of filter paper in the middle of their transparent ultracentrifuge cell so that an analysis is possible for determining the position of a single mono-disperse boundary.

A complete generalization of the mechanical method for rate of sedimentation is suggested by the author. It consists merely of a pile of horizontal circular solid disks, alternately wide and narrow, placed in the axis of a simple two-piece air-driven rotor. The small disks serve as spacing pieces for the larger ones between which the liquid is wholly immobilized, permitting ideal radial undisturbed sedimentation.

Particles or molecules of different sizes in the same fluid are detected and measured by varying the rate and extent of sedimentation in successive experiments.

In conclusion, it may be noted that even the Bechhold method may be used for distinguishing between mono-disperse and multi-disperse systems. It is easy to ascertain whether or not two substances are combined or associated with each other or sediment separately (as was done, for example, by Gratia in 1934).

It is evident that the problem of obtaining exact quantitative data on one or all of the quantities mentioned has been completely solved by simple means within the reach of every scientific laboratory.

JAMES W. MCBAIN
DEPARTMENT OF CHEMISTRY
STANFORD UNIVERSITY

[11] A. Tiselius, K. O. Pedersen and T. Svedberg, *Nature*, 140: 848–49, 1937.

BOOKS RECEIVED

DUMÉZIL, GEORGES. *Contes Lazes.* Travaux et Mémoires de L'Institut D'Ethnologie, Université de Paris, No. XXVII. Pp. 134. The Institute, Paris. 56 fr 25.

GUDGER, EUGENE W., Editor. *The Bashford Dean Memorial Volume; Archaic Fishes. Article VI. The Anatomy of the Frilled Shark.* Pp. 333–505. 127 figures. 7 plates. American Museum of Natural History, New York. $3.50.

Milestones in Medicine. Laity Lecures of the New York Academy of Medicine. Pp. vii + 276. Appleton-Century. $2.00.

SCHMIDT, CARL L. A., and FRANK W. ALLEN. *Fundamentals of Biochemistry; with Laboratory Experiments.* Pp. xiv + 388. 29 figures. McGraw-Hill. $3.00.

Science Reports of the Tôhoku Imperial University. Fourth Series (*Biology*). Vol. XII, No. 2. December, 1937. Pp. 321. Illustrated. Maruzen Company, Tokyo and Sendai.

STRONG, WILLIAM D. and others. *Preliminary Report on the Smithsonian Institution-Harvard University Archeological Expedition to Northwestern Honduras, 1936.* Smithsonian Miscellaneous Collections, Vol. 97, No. 1. (Publication 3445.) Pp. v + 129. 32 figures. 16 plates. The Institution, Washington, D. C.

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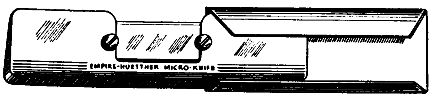

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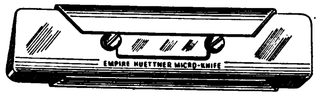

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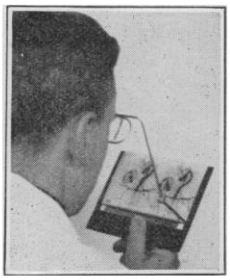

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