In order fully to understand this fundamental limitation of the mechanical analysis of atomic phenomena, one must realise clearly, further, that in a physical measurement it is never possible to take the interaction between object and measuring instruments directly into account. For the instruments cannot be included in the investigation while they are serving as means of observation. As the concept of general relativity expresses the essential dependence of physical phenomena on the frame of reference used for their co-ordination in space and time, so does the notion of complementarity serve to symbolise the fundamental limitation, met with in atomic physics, of our ingrained idea of phenomena as existing independently of the means by which they are observed.

(To be continued.)

Phases in South African Locusts

THE theory of phase variation in swarming locusts was first put forward about ten years ago, since when a considerable amount of data has been accumulated in its support. Most of the evidence, however, was either based on direct field observations, or on small-scale experiments which served only to prove the fact of the transformation from the solitary to the gregarious phase, and vice versa, but were insufficient for analytical study of the phenomenon and of its underlying causes. This gap has now been filled by a paper by Prof. J. C. Faure recording the results of four years' experimental studies on the phases of four species of locusts occurring in South Africa.*

The bulk of the experiments refer to the well-known brown locust of South Africa (*Locustana pardalina*, Wlk.), and most of them were repeated on the tropical migratory locust (*Locusta migratoria migratorioides*, R. and F.) which swarmed over enormous areas of the African continent last year; some corroboration of the results was obtained also from studies on the desert locust (*Schistocerca gregaria*, Forsk.) and the red locust (*Nomadacris septemfasciata*, Serv.).

The main result of the numerous breeding experiments made under a great variety of conditions is a final proof that the phase transformation is a scientific fact which can no longer be doubted. Indeed, Prof. Faure succeeded in producing the swarming phase from the solitary one, and vice versa, in the case of every species experimented upon.

Turning to the problem of the mechanism and the causes of the transformation, Prof. Faure's experiments confirm beyond doubt the importance of the density of the population in a given space. Locusts raised in crowded cages invariably assume the colour and structural characters of the swarming phase, and those kept in isolation become typical of the solitary phase. The factor responsible for the transformation appears to be the greater activity on the part of locusts in crowded cages, where every movement of an individual disturbs the others and the mutual excitation practically never dies down. This excessive activity results in an abnormally high rate of metabolism, and the striking reddish (or yellow) and black coloration of the hoppers of the swarming phase may be ascribed to the deposition in the chitin of some products of this abnormal metabolism; these unknown products are called 'locustine' by Prof. Faure. Structural differences by which the two phases can be separated may be explained also as a result of greater development of certain muscles in gregarious hoppers as compared with the solitary ones. This theory was tested in a series of experiments in which hoppers kept in isolation were forced to excessive activity, but unfortunately this proved to be a very difficult task, since none of the several very ingenious methods of stimulation applied to hoppers produced the desired degree of activity. Nevertheless, the results show clearly that a change towards the gregarious phase occurs in isolated but active hoppers, and there remains little doubt that solitary hoppers if forced to lead an excessively active life would produce a locust of the swarming phase.

A supplementary factor of the transformation is temperature, since the gregarious phase is obtained more easily and is more typically developed at higher temperatures. This is also in keeping with the above theory, since the general activity of hoppers is greatly affected by temperature conditions.

The results of some experiments suggest that transformation is caused not only by direct environmental influence on the developing individual, but that the conditions of adult life may also have an effect on the characteristics of the progeny. Thus, the progeny of adults of the gregarious phase show certain characters of that phase already in the first instar; Prof. Faure suggests that this is not a case of the inheritance of phase characters, but that the phenomenon may be due to the 'locustine' being handed down to the progeny in the nutritive yolk of the eggs. Indeed, a series of crossing experiments proved that phase characters are not Mendelian characters, and disposed effectively of some earlier suggestions in that direction.

An interesting point is raised by Prof. Faure's experiments on the coloration of solitary hoppers. As a rule, such insects are rather variable in colour but often exhibit a close correlation with the colour of the surroundings. The breeding of hoppers in uniformly painted boxes resulted in many cases in excellent general imitation of the background, even of the white, or black one.

* "The Phases of Locusts in South Africa". *Bull. Entom. Res.*, **23**, pt. 3, 1932, 112 pp., 25 pls., map.

These experiments throw an interesting light on the problem of the so-called sympathetic coloration in insects, and suggest a promising line of research. It was, however, somewhat unexpected that the green colour of environment is not imitated by hoppers, though they often become green on almost any background. Detailed experiments on the production of green coloration showed that it develops when hoppers are kept in a humid atmosphere and supplied with abundant moist food. However, attempts to discover chlorophyll in green hoppers failed, and the problem awaits further investigations.

Another interesting point raised with regard to the brown locust is the ability of its eggs to lie dormant for extremely long periods, up to 37 months after oviposition. A number of other equally interesting and important observations and experiments are recorded in the paper, which contains also a discussion of the bearing which these laboratory results have on the actual locust problem in the field. The knowledge of the phase transformation is already applied in practice in South Africa, and a careful watch for incipient congregations of solitary locusts in the field is kept. All such congregations are destroyed, with the result that the swarming phase has not appeared for several years. Further field ecological work will help in defining more precisely the areas favourable for the production of the swarming phase, and this will facilitate the anti-locust work still more, placing it entirely on the basis of prevention of outbreaks.

Prof. Faure's paper is exceptionally well documented by exact descriptions of experiments, tables of results and extremely well-reproduced coloured plates showing the remarkable range of the variation connected with the phase transformation of the species discussed. The results recorded constitute a great advance in our knowledge of the locust problem, and, moreover, they should go far towards demonstrating to biologists in general the outstanding interest of these insects, on which a number of fundamental problems can be studied better than on any other material.

B. P. UVAROV.

Obituary

PROF. JOHANNES SCHMIDT

THE science of oceanography has lost one of its most outstanding leaders by the death of Prof. Johannes Schmidt, director of the Carlsberg Physiological Laboratory, which occurred at Copenhagen on February 22 at the age of fifty-six years. His loss will leave a host of friends and colleagues all the world over with a sense of personal bereavement and regret, for being himself a great traveller with his home in Copenhagen, the headquarters of the International Council for the Exploration of the Sea, with which he was intimately associated, he was in close and frequent contact with all who were interested in the science of the sea. He was a man of quite exceptional charm, with a genius for friendship, always eager to help the work of others and to appreciate any help which others could give him in the execution of the bold schemes of research which he planned.

The name of Johannes Schmidt will no doubt be chiefly remembered for his solution of the age-old mystery of the life-story of the eel, but this success represented but a small part of his scientific activities and personal achievement. His versatility and breadth of view were striking. Starting his career as a botanist, his first expedition was to Siam in 1899, when he was editor and joint author of a report on "The Flora of Koh Chang". In 1910 he began at the Carlsberg Laboratory a series of investigations on hops (*Humulus lupulus* Linn.), publishing reports on their growth, biochemistry, and occurrence in the wild state in Denmark, and superintending researches on their fertilisation, development and the production of hybrids.

Later, under the inspiring influence of the late Dr. C. C. Joh. Petersen, and helped no doubt by his own enthusiasm for the sea—for first and last and always he was a good sailor-man—Schmidt became attached to the scientific staff which was carrying out Denmark's share of the programme of the International Council for the Exploration of the Sea. The importance of the fisheries at Iceland and the Faroes caused the Danish research vessels to go farther afield than those of the other powers, and the steam trawler *Thor* carried out regular cruises from Copenhagen to the northern waters of the Atlantic.

This was Schmidt's training ground for the extended expeditions in small vessels which he eventually undertook. At first he concentrated on the description of post-larval and early adult stages of fishes, especially of the cod family, and their distribution and migrations in relation to temperature and other physical characteristics of the sea-water. This was necessary pioneer work which has stood the test of time.

In May, 1904, Schmidt was collecting young fishes with large pelagic nets, and captured in the North Atlantic west of the Faroes one specimen of the *Leptocephalus brevirostris*, which Grassi and Calandruccio in 1896 had proved to be the larva of the common fresh-water eel. In the following year (1905) the *Thor* succeeded in capturing, at the end of May, a small number of specimens of *Leptocephalus* over the deep water off the west of Scotland, and still farther south the numbers increased over depths of 1,000–1,500 metres, until, in water of this depth in the central part of the plateau off the mouth of the English Channel, up to 70 per two hours' haul were obtained with nets towed with about 300 metres of wire. A few hauls taken in September, west of the Hebrides, showed that the larvæ were already beginning to meta-