bacillus from secretions of influenzal patients and grown it in separate culture, they have failed in the crucial test of inoculation in animals to reproduce influenza.

This brings us to our next difficulty. In the absence of a certain bacteriological test, a further obstacle is that there is no characteristic symptom in influenza, like the rash in scarlet fever, or the throat membrane in diphtheria. On the contrary, what is supposed to be influenza assumes several types. At present cases with gastric symptoms are common, with few or no respiratory complications in a proportion of cases. But are we certain that these two types are the same disease? There is much evidence that commonly there is mixed infection; and in the great epidemic of 1918-19, which destroyed more of mankind than the great war, much of the mortality was due to secondary (or primary) invasion of hæmolytic streptococci.

On such an apparently simple point as the immunity conferred by a single attack the evidence is discrepant. Although it did appear that many of those attacked in the summer epidemic of 1918 escaped attack in the terrible epidemic of the following winter, the evidence is not satisfactory. It appears clear that if immunity is conferred by an attack, the immunity is of short duration; and this brings out the further point that inoculation of a vaccine prepared from the Pfeiffer bacillus and the associated coccal organisms cannot be expected to do much good, except perhaps in diminishing the seriousness of pulmonary complications.

Nor have we any plausible explanation of the remarkable change in the age incidence of deaths from influenza. In the epidemic of 1889-92 some 60 to 70 per cent. of all the recorded deaths from influenza occurred among patients more than 55 years old; in the recent epidemic, fatal cases at these ages formed only some 12 per cent. of the total, while about 70 per cent. of the total deaths were of patients less than 35 years old. Does this imply that we have recently been concerned with a different infection, or what is the explanation?

It is noteworthy that coincidently with epidemic influenza, certain other diseases, like cerebro-spinal meningitis and encephalitis lethargica, have prevailed to an exceptional extent. This has been explained by Dr. Hamer and others as implying that we are, in fact, in the grip of a single infection assuming multiform manifestations. But the association was not evident in the 1889-92 epidemic; and it is equally open to us to assume—and there are good grounds for maintaining—that all these diseases, each specific in character, are favoured by

the same "epidemic constitution"—or what is concealed under this designation—and that they are not identical diseases.

The preceding incomplete review of the chief of the unknown factors in influenza must necessarily be somewhat depressing. It is well, therefore, to look for a moment at other diseases which, like influenza, at irregular intervals and for unknown reasons, assume world-wide movements, invading mankind in many countries. Among these cholera, plague, and smallpox may be specially mentioned. Yet each of these is entirely controllable, and, so far as a large part of the world is concerned, has been controlled. Cholera is now kept within bounds and almost non-existent in every country with elementary sanitation. Plague is controllable to the extent to which infection by rats and their fleas is stopped: a practicable programme. In smallpox there is the important additional protection of vaccination, and against a population protected by this measure waves of smallpox infection break for ever impotently. The last-named illustration is significant from the point of view of influenza. Both infections are usually received by the respiratory tract. Against one vaccination affords protection, against the other results of inoculation have been more than dubious. The world is waiting for further light. How is influenza and how are respiratory infections in general to be prevented? This is the unconquered region of preventive medicine. It will doubtless be occupied eventually, but after how much delay and on what plan it would be rash to hazard a prophecy.

An Elusive Group of Marine Organisms.

The Free-living Unarmored Dinoflagellata. By C. A. Kofoed and Olive Swezy. (Memoirs of the University of California, Vol. 5.) Pp. viii+562+12 plates. (Berkeley, California: University of California Press, 1921.)

THE University of California at Berkeley, Cal., supported no doubt by large revenues from the State, sets a noble example in publishing valuable contributions to knowledge. In addition to about thirty octavo series in zoology, physiology, and other sciences, the University Press issues large quarto Memoirs, of which the fifth volume is Kofoed and Swezy's "Dinoflagellata," a very notable work of 570 pages and twelve coloured plates. It is the result of observations made by Prof. Kofoed and his pupils over a series of years from 1901 onwards at the marine laboratories of the University of California and the more recently established Scripps Institution for Bio-

logical Research at La Jolla—both by work at sea off the coast of Southern California and by investigation of the beach sands.

The Dinoflagellata form an exceedingly important source of the food supply of the sea both in numbers and in the total mass produced. As synthetic producers of carbohydrates, proteids, and fats they hold high rank amongst microscopic marine organisms, and in abundance they are second only to the diatoms in the plankton, while locally and on occasions they may far outnumber them. These local massive developments are the all but universal cause of the discoloured seas and of the phenomena of luminescence. The present monograph deals with the least-known and most elusive members of the group, the naked or unarmoured forms.

One great difficulty in their investigation is the extreme delicacy of these organisms and their tendency to undergo cytolysis in even a few moments' exposure to light under the microscope. They are unfortunately most sensitive to the action of fixing re-agents, and almost instantaneous distortion and disruption prevent the preservation of permanent preparations. The investigator is therefore limited to rapid and immediate observation of the freshly captured living and usually very active organisms. It is only on a coast such as that of Southern California, where pure oceanic water with a rich pelagic fauna is brought within a few miles of a laboratory equipped like the Scripps Institution, that work such as that of Prof. Kofoid could be carried on. A specially devised net of the finest silk is towed for a very short time at a depth of 80 metres, the catch transferred to a relatively large volume of water, rushed ashore in a fast motor-boat (30 miles an hour), and divided up at once for the microscopes of half-a-dozen assistant observers, a surprising number of new and remarkable forms in exceptionally fine condition being revealed. Ordinary methods of plankton collection and preservation yield no traces of these extremely delicate organisms. This is an excellent example of new and refined methods at sea, such as can be adopted only in connection with a biological station, which are giving new results of great scientific interest. It must not be supposed, however, that all these Dinoflagellates are confined to oceanic water. Some are neritic, and species of *Amphidinium*, for example, have been found in vast numbers on damp beach sand at several localities in England, California, and elsewhere.

Many of these new unarmoured Dinoflagellates are brilliantly coloured, as the beautiful plates abundantly show, and some are wonderfully

organised and specialised for such minute protozoa. Some possess, amongst other "organelles," a complicated ocellus or "eye," with lens, pigment mass, and sensory core, as well as a large mobile tentacle, and groups of nematocysts resembling those of *Cœlenterata*. The whole group and its subdivisions and the numerous genera, sub-genera, and species are discussed most fully from every point of view—general morphology and relations, minute structure, physiology, history, and distribution. In their nutrition the majority of marine unarmoured Dinoflagellates are holozoic, and even some of those that contain chromatophores and were hitherto supposed to be holophytic are now found to contain ingested foreign bodies in the cytoplasm. What is known of the life-cycles, including encystment, spore formation, binary and multiple fission, and possibly conjugation—and the effects of parasitism in some forms—are all discussed, but it is evident that much has still to be discovered in regard to these matters.

In regard to the evolution of the group, our authors show that it probably arose from the Cryptomonads, and the Dinoflagellata of to-day represent the terminal twigs of a phylogenetic branching. The attempt to find ciliate affinities through the remarkable genus *Polykrikos* is rejected as a misinterpretation. A new form, *Protodinifer*, is regarded as bridging the gap between the two main groups of Dinoflagellates, the *Diniferidea* and the *Adiniferidea*, but it may be pointed out that "*Protodinifer*" is clearly identical with the *Pelagorhynchus marinus* of Pavillard (*Comptes rendus*, January, 1917). Amongst notable changes in the more familiar classifications of the text-books are the removal of *Noctiluca* from the *Cystoflagellata* and its inclusion in the *Gymnodinoidæ*, and the abolition of the *Pyrocystaceæ* of Murray, Apstein, West, and others, as these latter organisms are now to be regarded as merely phases in the life-history of other Dinoflagellates.

In addition to the nematocysts in *Nematodinium* and *Polykrikos* and the ocellus in *Pouchetia*, etc., the most remarkable further specialisation is seen in the highly developed appendage or "prod," with protractile and retractile fibrillæ, which reaches its climax in the genus *Erythropsis*. The authors, in pointing out the *cœlenterate* resemblances of the nematocysts and the tentacle placed on the edge of the sulcus or mouth, and also the tendency to a multicellular condition seen in the "chains" of *Ceratium* and the two-, four-, or eight-celled "*somatella*" of *Polykrikos*, suggest that "pelagic Dinoflagellata may have given rise

to simple pelagic Coelenterates in which cell boundaries and cell layers may have played only a secondary and belated part as the size of the organism increased."

The economic importance of these organisms is great, both as a food supply and also occasionally as a destructive agency. It is well known that they form a large percentage of the stomach contents of sardines and other small fish. At times they are the dominant forms of the plankton, and have been recorded by Kofoed as the cause of outbreaks of "red water" on the Californian coast and elsewhere which may be a menace to the health and life of slow-moving or bottom-living animals which, being unable to escape from the infested area, die in quantity and are cast up in masses on the shore. Such discoloration of the water, due to species of *Gymnodinium* and *Gonyaulax*, are recorded as extending sometimes (August, 1917) for a hundred miles or more along the coast.

To point out a few slips in such a splendid memoir may seem ungracious, but Prof. Kofoed would probably prefer to have friendly criticism: In the phylogenetic diagram on p. 84, have not *Protodiniifer* and *Oxyrrhis* exchanged places, should not *Protodiniifer* be *Pelagorhynchus*, and, near the top of the diagram, should not *Nematopsis* be *Nematodinium*? The text-figure on p. 509 is evidently printed upside down, and in Fig. F (p. 30) the numbers 2, 3, and 4 are misplaced. Some of the references to figures in the text are not correct, but the careful reader will notice these for himself and will readily discover what is intended.

So many species are described, redescribed, or discussed, and the synonymy and history are given so fully, that the memoir is truly a monograph of the group, and will be found indispensable by all who work at these important lower organisms.

W. A. HERDMAN.

The Theory of Probability.

A Treatise on Probability. By J. M. Keynes. Pp. xi+466. (London: Macmillan and Co., Ltd., 1921.) 18s. net.

DR. KEYNES'S book is a searching analysis of the fundamental principles of the theory of probability and of the particular judgments involved in its application to concrete problems. He adopts the view that knowledge may be relevant to our rational belief of a proposition without amounting to complete proof or disproof of it, and treats the probability as a measure of this relevance.

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Otherwise he does not attempt to define "probability," regarding it as a concept intelligible without further definition. In this respect, as in several others, he is in agreement with the views expressed by Dr. Wrinch and the present reviewer (*Philosophical Magazine*, vol. 38, 1919, pp. 715-31), and some comparison of the two presentations may not be out of place.

Previous writers have practically all assumed that probabilities can be expressed by numbers, and this assumption was put into precise form in the paper mentioned. Dr. Keynes departs completely from tradition on this point. Defining an "argument" as the process of passing to knowledge about one proposition by contemplation of it in relation to another of which we have knowledge, he denies not only that the probabilities of all arguments can be expressed by numbers, but also that they can be arranged in a one-dimensional series at all. Thus the probability of one argument may be neither greater than, equal to, nor less than that of another. The difference in actual application between this theory and ours appears likely to be slight, for the definitions and hypotheses are such that practically any two probabilities that one needs to compare are comparable. From these the formal theory is soundly developed.

The principle of non-sufficient reason, or indifference, asserts that we assign equal probabilities to propositions if we have no reason to do the contrary. The author criticises severely many previous applications of this principle (so severely that an unprepared reader is likely to be betrayed into expecting him to reject the principle altogether). He finally modifies it by saying that neither of the propositions deemed equally probable may be expressible as the disjunction of two mutually inconsistent propositions, of the same form as itself, and both consistent with the data. His precise statement of this important principle makes it possible to evaluate a large class of probabilities that could otherwise be only estimated, and is a most useful advance.

Dr. Keynes rejects definitely the view of Jevons and others that if any two alternatives are exhaustive and mutually exclusive, and we have no reason to prefer one to the other, the probability of each is $\frac{1}{2}$. His reasons for believing that this view leads to contradictions, however, appear incorrect. He says on p. 43: "If, for instance, having no evidence relevant to the colour of this book, we could conclude that $\frac{1}{2}$ is the probability of 'This book is red,' we could conclude equally that the probability of each of the propositions, 'This book is black' and 'This book is blue,' is also $\frac{1}{2}$. So that we