

carry out systematic quantitative plankton investigations all through the winter, in combination with hydrographical researches, in parts of the Atlantic like the sea round the Azores, where the plankton is known to be scanty during the summer, but where during the course of winter vertical circulation might be expected to create different conditions of existence.

Whipple.

In this connection it should be mentioned that the influence of vertical circulation upon the production of plankton-algæ in fresh water has long been known to biologists. It has been pointed out by Whipple, who showed that the maxima of diatoms in particular coincide with the seasons when vertical circulation takes place, namely autumn and spring. And in the sea, too, it seems that diatoms, with their power of rapid augmentation, are the first to respond to improved conditions of nourishment.

Which of the essential nutritive substances are the chief limiting factors in the sea, it is impossible to say as yet. Probably, however, nitrogen is the most important, and next to it, perhaps, more especially in the case of diatoms, we may put silicic acid. Brandt and Nathansohn have both discussed the occurrence of these substances, but we need further and more conclusive information than what we now possess. Nathansohn has likewise considered the possibility of carbonic acid occurring "in minimum." This seems paradoxical, of course, since there are comparatively large quantities of it in sea-water. Still the greater part is combined in the form of carbonates, and only a very small portion is set free by dissociation at any given moment, so as to become available for the plants. How much there is in this form will depend on the alkalinity of the sea-water and on the temperature. When the free carbonic acid is used up by the plants, fresh quantities will gradually be absorbed from the atmosphere, though this may take place so slowly that there need not necessarily be any equilibrium between the carbonic acid tension in the atmosphere and at the surface of the sea. It is accordingly quite conceivable that the shortage may for a time be considerable enough to stop the algæ from assimilating carbonic acid. When the temperature is high the quantity of free carbonic acid in the sea-water will *ceteris paribus* be less than when it is low, and this also may help to explain the relatively poor production in warm seas. Variations in the tension of carbonic acid, however, have not as yet been sufficiently studied.

The organic substances built up by pelagic algæ unquestion-