A. CHANGES IN THE PHYTOPLANKTON

by M. Rosenberg.

It has long been recognised that the distribution of freshwater organisms, especially of the free floating community, the plankton, varies much less the world over, than that of terrestrial communities. This fact can be attributed to the peculiar nature of the environment, water, which shows climatic fluctuations to a lesser extent than land, thereby evening out the extreme differences which depend on geographical position. Great differences in conditions are, however, found in a vertical section of a large body of water, especially in regard to light, temperature and chemical substances. As every large body of water contains in itself a gradient of these important factors, and parallel with this supports plants and animals tolerating either a wide range of conditions, or adapted to a strictly limited layer in the water, the additional fluctuations due to geographical situation are of only secondary importance.

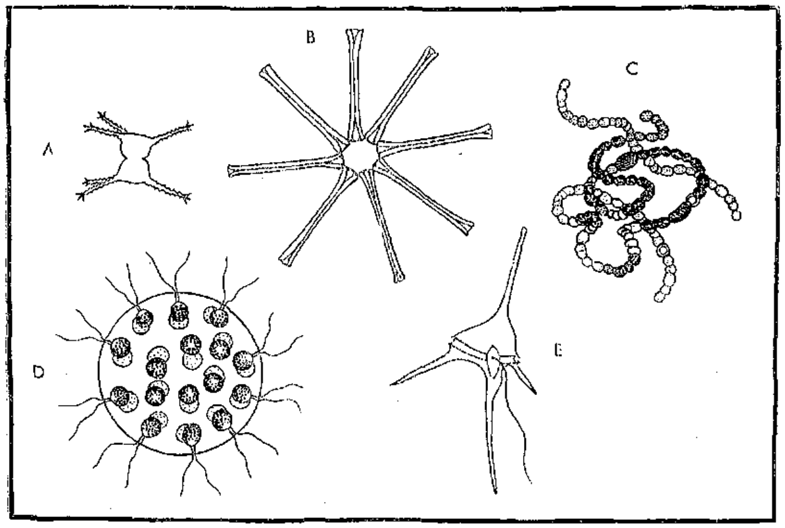

FIGURE 3. Representative species of planktonic algae. x about 200.
A. a desmid, *Staurastrum paradoxum*
B. a diatom, *Asterionella formosa*
C. a blue-green alga, *Anabaena flos-aquae*
D. a colonial green alga, *Eudorina elegans*
E. a dinoflagellate, *Ceratium hirundinella*

In some temperate regions observations of plankton and general conditions have been carried on for many years and so conclusions can be drawn from general correlations. The relationship between the various factors and the organisms is complicated, so it is only in a few cases that we can recognise a causal connection.

In the English Lake District the phytoplankton has been studied qualitatively for many years, by W. and G. S. West and by W. H. Pearsall. The number of different species is very large: 160 have been found in the plankton of Windermere alone. Representative members of each of the principal groups are shown in figure 3. More recently quantitative work has been done, especially on Windermere and Esthwaite water, and interesting comparisons can now be drawn between the different periods over which this work has been spread. A number of species have appeared, which had not been observed before, and at the same time some previously dominant species have disappeared altogether. As examples for the north basin of Windermere, *Chrysocapsa planktonica* has appeared regularly for the last three years but had not been recorded before, and *Uroglenopsis Americana*, first observed by Pearsall in 1932, has since been found every year in large numbers. In the south basin of Windermere *Cosmocladium Saxonicum* is now a permanent member of the plankton, probably introduced from Esthwaite water. In Bassenthwaite Lake the disappearance of *Micrasterias Mahabuleshwarensis*, var. *Wallichii*, which used to be present in large numbers, has caused much comment. Similar examples could be added for smaller lakes and tarns which have been studied. According to general observations, not however based on counts, the water of Windermere seems to be undergoing a regular change which indicates a steady increase in the amount of dissolved organic matter; this is confirmed by the increase in estimated numbers of blue-green algae and the presence since 1932 of *Uroglenopsis Americana*. The probable cause of this change is the increase of sewage entering the lake, as a result of the steadily increasing human population of the neighbourhood. Such effects are most likely to be noticed in waters which are poor in nutritive substances (oligotrophic), as are the English lakes. Likewise in the Alps it has been observed in several cases in similar types of waters, that following the building of hotels on the shores of small mountain lakes and the permanent addition to the water of chemical substances derived from sewage, sudden changes in the phytoplankton have occurred. In rich agricultural country, such as limestone or chalk districts where the water as a rule can support a large biological community, the addition of nutritive substances of organic or inorganic nature is likely to have much less effect, and other factors, such as light and temperature are of relatively greater importance.

In connection with work on the growth rate of trout, a tarn in the neighbourhood of Wray Castle was treated with bone meal and interesting changes in the phytoplankton were observed. The original typical desmid plankton gave way to *Volvox aureus* as the dominant form and this was followed later in the year by a mass development of the blue-green alga, *Anabaena flos-aquae*, a form typical of more developed lakes. By adding chemicals of importance for plant growth a definite but only temporary change of the phytoplankton could be observed; the plankton reverted to its original composition in about two years after the treatment. A second treatment is being given this spring and the effect will be carefully followed.

Changes in the composition of the plankton throughout the year are being observed under a variety of climatic conditions. In years when the rainfall and temperature approximate to the normal, the sequence of dominant organisms in different layers of water is more or less consistent. In waters which are relatively poor in nutritive substances the relation between these substances and the abundance of important plankton algae is very clear, but in rich waters the chemical relationship may be obscured by other factors. In Windermere it has been clearly shown that the maximum development of phytoplankton occurs at a time when the water is rich in dissolved substances. The depletion of these substances, a result of repeated multiplication of the algae, is followed by a sudden drop in their numbers.

Owing to different requirements in the various groups, there is an annual periodicity in sequence and proportion of species. Figure 4 shows the relative proportions of the five principal groups throughout the year. Diatoms, which require higher concentrations of lime and silica as compared with other groups, especially desmids, are most abundant in the spring. A second mass development of diatoms, although on a smaller scale, is usually observed in the autumn, in most cases following heavy rain or floods, which replenish the lake with the nutritive substances. After the sudden decline of the diatoms the organic matter resulting from the decomposition of the diatom

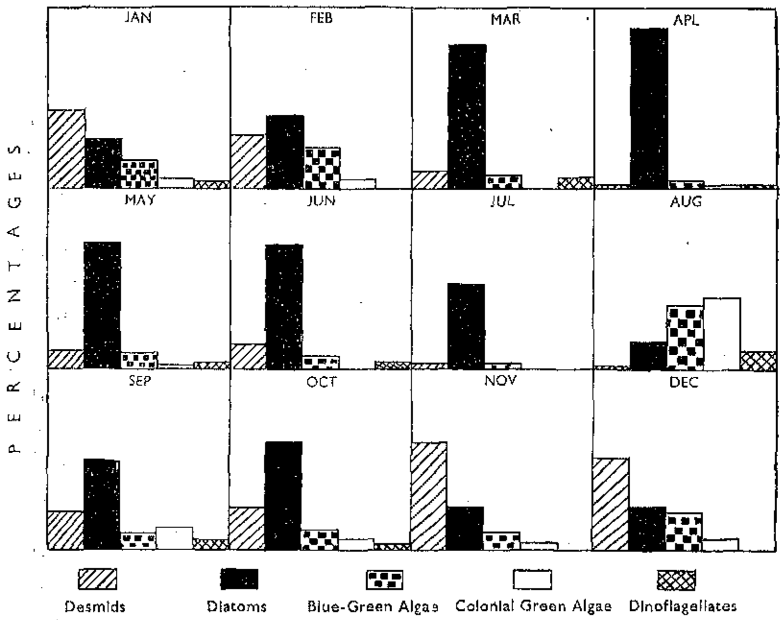

FIGURE 4. Seasonal variation in the constituents of phytoplankton in Windermere (north basin).
The histograms represent percentages of the total phytoplankton made up by each group of algae. They are based on counts of well over 200 individuals each month.

cells, supports a large population of blue-green algae. Colonial green algae, for example *Eudorina*, also seem to be favoured by the organic matter dissolved in the water. It has been found in several cases that chemical analyses for dissolved organic matter are not immediately reflected in the constitution of the phytoplankton, but there is a lag of three or four weeks before the peak development of blue-green algae is reached. This is shown by a comparison of figures 4 and 5.

Detailed work on the occurrence of these various groups and species of algae and the chemical nature of the water at the time of or shortly before their appearance, has given much information as to the differences in their requirements. The sequence of the various groups has been established as a regular phenomenon, provided that climatic factors and human interference are not subject to big changes. Only in few cases, however, can we understand the cause for the sudden appearance of a species; more frequently we can understand its sudden disappearance.