# ALGAL BLOOMS

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In lakes, rivers, and oceans certain algae multiply to such an extent that they form dense surface or sub-surface scums. Such scums or blooms, sometimes called phytoplankton "pulses", persist for a short time, often bringing about extensive fish kills. One of the first records of fish mortality is mentioned in the Bible as the first of the seven plagues of Egypt—"and all the water that was in the Nile turned to blood. And the fish in the Nile became foul, so that the Egyptians could not drink water from the Nile; and there was blood throughout all the land of Egypt." (Exodus VII, 20, 21).

Many instances of algal blooms and their relationship with the mortality of fish and other animals have been observed in different parts of the world, from Australia to Japan, and Chile to Alaska (Brogersma - Sanders, 1948; Koob, 1971). Blooms in nature are produced by a variety of algae, not all of which are known to bring about detrimental effects. In the oceans, almost all mass fish kills by algae have been attributed to certain flagellates (Brogersma-Sanders, 1948; Florida Conservation News Vol. 6, p. 4-5, 1971). Inland, on the other hand, the blooms that cause harmful effects may be formed by many algae of which the blue-greens predominate.

Toxic blue-green algal blooms may have harmful enough effects to kill many waterfowl, shore-birds, rodents and domestic animals as large as pigs and horses (Olson, 1964) and in some instances, certain types of gastro-intestinal disorders in man have been attributed to toxins produced by them (Schwimmer and Schwimmer, 1964). In southern Saskatchewan the blue-green algal blooms common in lakes and rivers are known to cause considerable damage to some fauna. In the Qu'Appelle lakes, many cases of mortality of a variety of animals have been related directly or indirectly to blue-green algal blooms (Hammer, 1968). Some researchers have been able to isolate toxic strains of blue-green algae and a few of the toxins produced by them have been identified (Gorham, 1960, 1962, 1964; Gorham *et al.* 1964).

Appearance of algal blooms is a phenomenon associated with the natural eutrophication of lakes. Eutrophication is the aging process that all fresh water lakes undergo. "Young" lakes are typically cold water bodies high in oxygen content but low in nutrients, total living material, and the diversity of species present. Such relatively sterile lakes are said to be oligotrophic and are well typified by the lakes of northern Saskatchewan. As an oligotrophic lake ages, mineral nutrients and organic matter tend to accumulate from runoff; water temperature, species diversity, and the total amount of living material present increases. Lakes having these latter qualities are said to be eutrophied and are exemplified in Saskatchewan by the well-aged lakes of the Qu'Appelle river chain where algal blooms occur commonly.

In an ecological survey of the Qu'Appelle lakes, Hammer (1967, 1968) has related the occurrence of algal blooms to a few environmental factors such as temperature, accumulation of phosphates, and the interactions of bloom-forming species. Although blooms occur as a natural phenomenon, their intensity can be compounded by the inevitable spring run-off which may carry in abnormal amounts of nutrients from agricultural fields, cattle feed lots, sewage treatment plants, etc. Good examples of the role of such human influence in the stimulation of algal blooms are the lakes of Amchitka Island, Alaska, where pollution from military camps constructed during World War II has, in a short period of time, changed oligotrophic lakes into

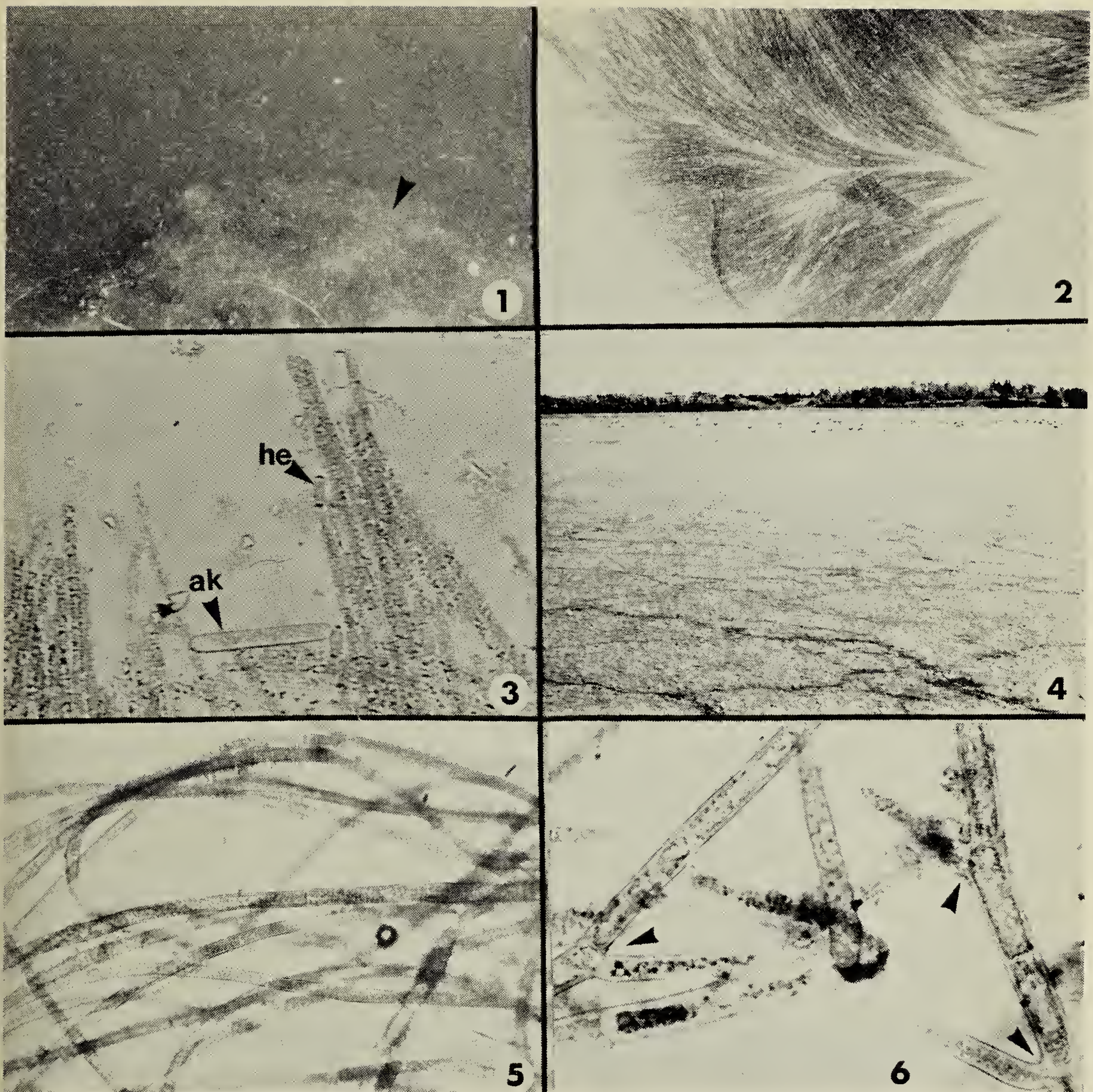


Fig. 1 Close-up picture of *Aphanizomenon* and *Spirogyra* in Wascana Lake. Arrow points at the slimy sub-surface of *Spirogyra*. Flakes of *Aphanizomenon* are visible everywhere.

Fig. 2 One of the flakes of *Aphanizomenon* as seen under microscope. Note bundles of trichomes or filaments. X 90.

Fig. 3 Enlarged view of the same to show the filaments, heterocysts (he) and akinetes (ak). X 765.

Fig. 4 Picture of surface scum of *Rhizoclonium*.

Fig. 5 A few filaments of *Rhizoclonium* under microscope. Note the absence of branching. X 225.

Fig. 6 Filaments of the same collected late in the season to show the mode of branching. Arrows indicate branching. X 765.

eutrophic ones supporting immense blooms of blue-green algae (Koob, 1971). In Lake Erie, the accumulation of nutrients from sewage, industrial wastes, and agricultural run-off has stimulated the growth of some of the most noxious types of algae and in the words of Dasmann (1968) turned Niagara Falls, which receives its water from Lake Erie, into "the nation's most spectacular sewer outfall."

While algal blooms form good indicators of pollution, they may themselves, under certain circumstances,

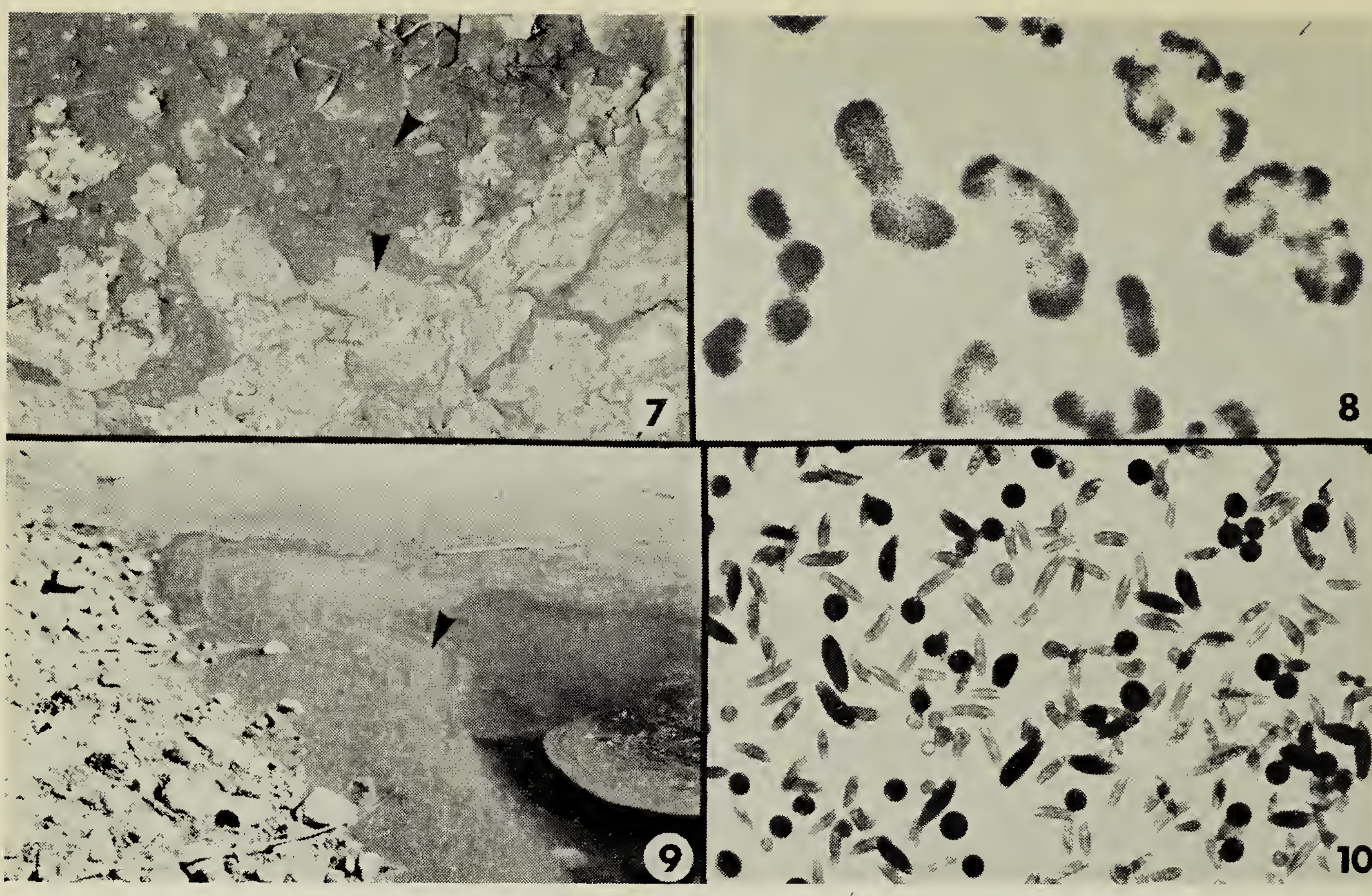


Fig. 7 Close-up picture of the surface scum of *Microcystis* (arrows). Dried flakes appear lighter.

Fig. 8 Same under microscope to show colonies. X 300.

Fig. 9 Surface scum of *Euglena.*

Fig. 10. *Euglena* cells under microscop. X-300.

become pollutants. Some algae have the unique capacity of accumulating and concentrating nutrients such as nitrates, phosphates, etc. When the algal cells die and disintegrate, these nutrients are released into the lakes which may then become overly enriched.

Algal blooms that are associated with pollution or eutrophication of lakes have been reported and the factors that control their development have to a certain extent been determined by using a wide variety of limnological techniques (Hammer, 1964, 1969; Warwick, 1967; see Odum, 1971). However, very little information is available with regard to the life histories of these algae. Information on how bloom-forming algae respond to a variety of environmental factors is wanting. Knowledge of the mechanisms of reproduction under natural conditions are amost totally lacking as is information on seasonal variation of the algae.

**Algal Blooms of Wascana Lake**

Some years ago, one of the authors undertook a project to take an inventory of the algae of Wascana Lake and to recognize the ones that formed blooms. In this connection, a checklist of the algae of Wascana Lake has recently been published (Raju, Young, and Hines, 1971). According to this checklist, only a few of the algae were found to form abundant blooms, thereby spoiling the aesthetic value of the lake and possibly endangering the lives of some domestic and wild animals frequenting the area. Some other algae were also abundant and showed possible bloom-forming tendency.

For the present purposes, the bloom forming algae of the Wascana Lake can be divided into three groups or divisions:

1. *Chlorophyta* (green algae), e.g. *Rhizoclonium* and *Spirogyra,* have chloroplasts with two major green pigments, chlorophyll *a* and *b*, which are essential for photosynthesis. *Rhizoclo-*

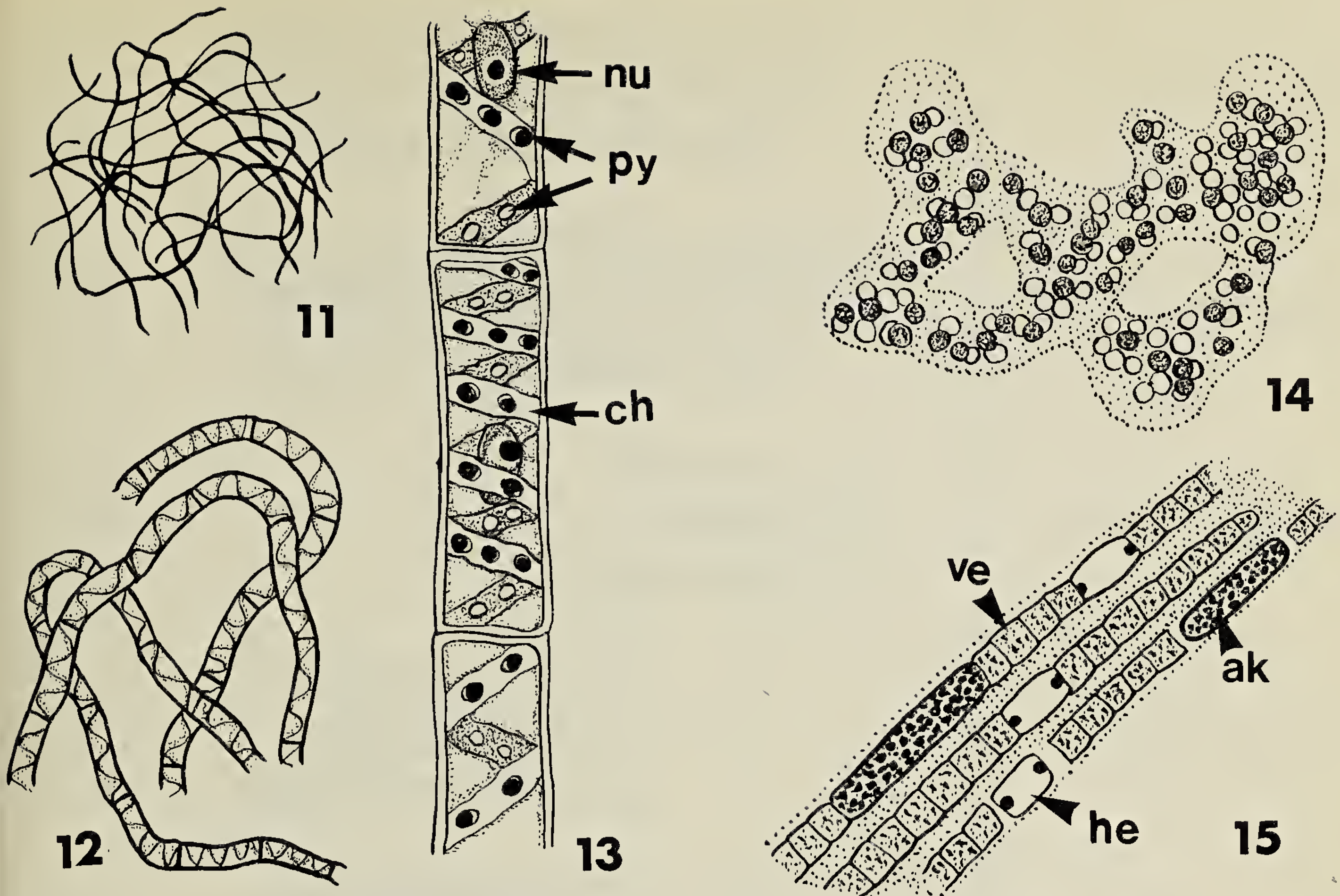


Fig. 11-15 Diagrammatic sketches of algae. Fig. 11: Unbranched filaments of *Spirogyra* tangled up. Fig. 12: Enlarged view of a few filaments showing cellular details. Note ribbon-shaped helical chloroplast (ch) with pyrenoids (py) and nucleus (nu). Fig. 14: enlarged diagram of a colony of *Microcystis* of the type seen in Fig. 8. Note mucilaginous matrix in which many cells are embedded. Fig. 15: A bundle of filaments or trichomes of *Aphanizomenon* showing akinetes (ak), heterocysts (he) and vegetative cells (ve).

*nium* is a filamentous form with little or no branching (Figure 5) which may form branches late in the season (Fig. 6). The filaments of *Spirogyra* form a dense slimy mass (Fig. 1) and they are unbranched (Fig. 11, 12). The cells of *Spirogyra* contain spirally arranged ribbon-shaped chloroplasts which may vary in number. In the present form, however, the cells have one chloroplast per cell (Fig. 13).

2. *Cyanophyta* (blue-green algae) do not contain structures equivalent to chloroplasts. The pigment is spread throughout the cell in the form of fine granules. These granules are known to contain major pigments, chlorophyll *a* (green), c-phycocyanin (blue) and c-phycoerythrin (red). These pigments together give a blue-green or sometimes red coloration. The ones that form blooms in Wascana Lake are blue-green. e.g. *Microcystis* and *Aphanizomenon*. *Microcystis* is a unicellular form dividing rapidly to hundreds and thousands of cells which remain embedded in a common mass of mucilage. Such colonies are microscopic and show a variety of morphological forms (Fig. 7, 8, 14). *Aphanizomenon* is a filamentous form surrounded by slimy mucilage. Several filaments are held together in a mucilaginous matrix to form very small flakes which are visible to the naked eye (Fig 1). These flakes under higher magnification show a variety of forms (Fig. 2). The unbranched filaments, commonly called trichomes, are made up of minute uniform-size cells. These are the vegetative cells. At certain stages in the life cycle some of these minute cells become modified to form heterocysts and akinetes (Fig. 3, 15). The heterocyst cells under a microscope appear optically empty and are known to con-

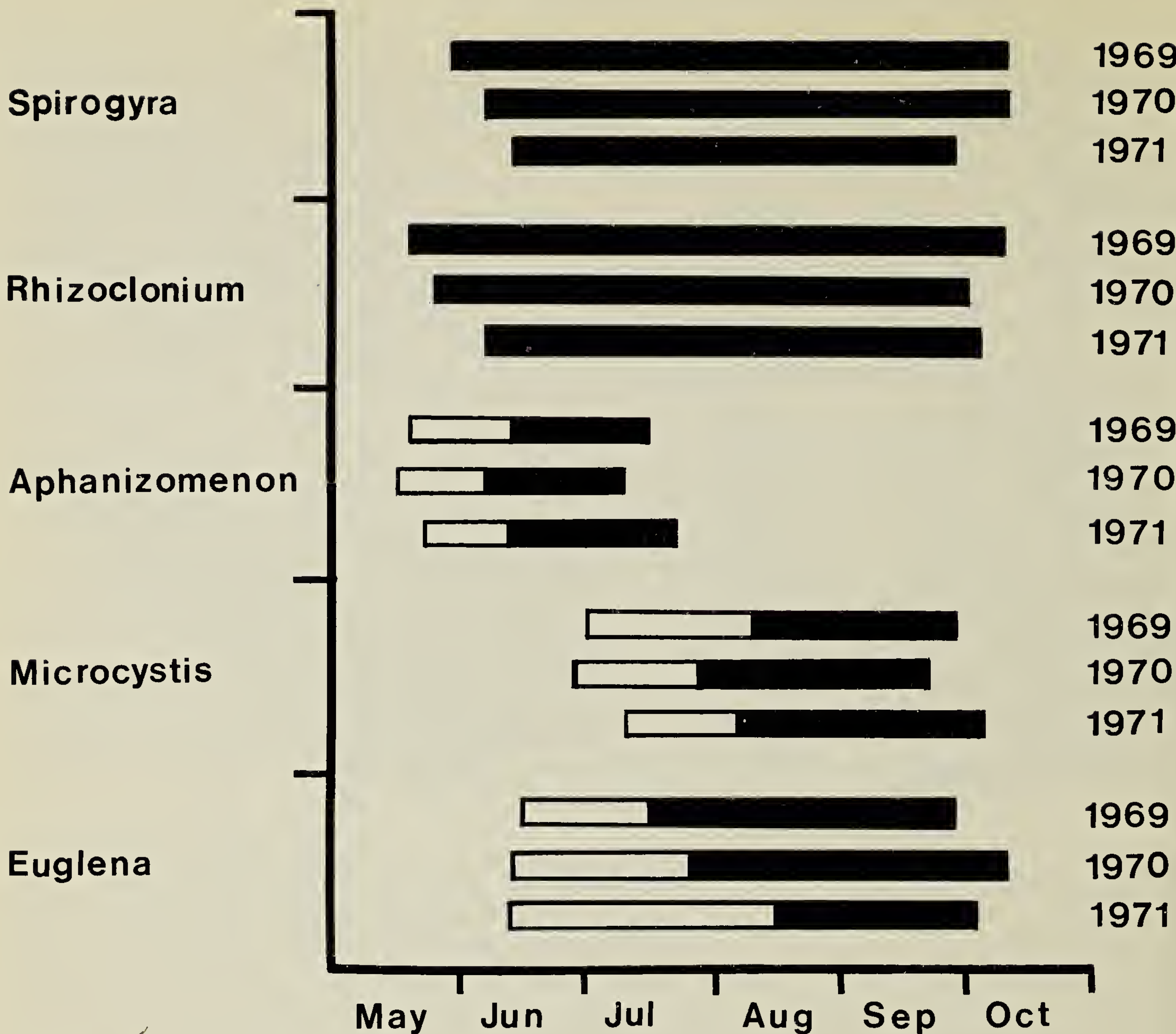


Fig. 16 Seasonal changes in the morphology of populations of algae that form blooms in Wascana Lake. Solid bar indicates bloom period of the algae. Open bar shows the occurrences of the alga.

tain special enzymes (Stewart, Haystead and Pearson, 1969). These cells are reported to be the sites where the nitrogen in the atmosphere is fixed into the cell. The akinetes, on the other hand, are large optically dense cells with abundant storage material. These cells, after they are detached from the filament, can over-winter and germinate in the following spring thus forming new filaments.

3. *Euglenophyta* (Euglenoids or flagellates) hav e chloroplasts with green pigments, chlorophyll *a* and *b*. Some carotenoid pigments are present which under certain circumstances become so abundant that cells appear red in color (Raju, 1970). These algae are generally solitary and can swim around with the help of a whip-like flagellum (Fig. 10) and at certain times of the season the cells may aggregate to form a surface scum or bloom, e.g. *Euglena*.

In Wascana Lake, only 5 genera (2 green, 2 blue-green and one flagellate) formed blooms. For each of the genera, the time of origin of the bloom and the length of its persistence varied from year to year (Fig. 16). The pattern of succession of the blooms was fairly consistent during the observation period.

The filamentous, branched, green alga, *Rhizoclonium* (Fig. 5, 6) appeared early in the growing season (Fig. 16). This formed a persistent green or yellowish - green surface "mass" and died out completely in autumn. *Spirogyra*, another green alga was correspondingly similar to *Rhizoclonium* although not so abundant as the latter. It formed a surface or sub-surface bloom in some areas of the lake in late summer and in autumn. The blue-green unbranched filamentous species. *Aphanizomenon* (Fig. 1 2) appeared early in the spring and formed an extensive sub-surface bloom in the lake. It lasted until about the middle of July (Fig. 16). The algal filaments were held together by slimy material and appeared like flakes. These flakes showed a variety of morphological patterns which could be recognized under the microscope (Fig. 2). Dense aggregation of such flakes in some areas corresponded to the oft-described thick "pea soup." Another blue-green, *Microcystis* (Fig. 7, 8) appeared very late in the summer (Fig. 16) when water temperature was high. It persisted until the early part of autumn. During its growth the colonies showed a variety of forms and very often it was difficult to identify the species. The flagellate, *Euglena*, bloomed along with *Microcystis*. Although *Euglena* cells were observed in spring, they did not bloom until late July (Fig. 16).

The succession of blooms, particularly of blue-green algae, are known to be related to factors such as temperature, nutrient concentrations, etc. (Hammer, 1964). In general, the phytoplanktonic blooms in temperate countries are known to appear in spring and autumn and they are reported to be related to nutrients (Odum, 1971). High concentrations of nutrients in the winter and their subsequent depletion in the spring may be correlated with algal blooms in the spring. The autumn algal blooms are due to the stimulatory effect of nutrients accumulated during the summer by the disintegration of spring blooms. Whatever may be the correlative factors, the mechanisms of blooming of some algae and the relationship between bloom-forming algae and their reproductive cycles are not clear. Attempts are being made to gain a better insight into the mechanisms of bloom formations in certain algae and to determine the role of environmental factors on the bloom-forming capacity of the algae.

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