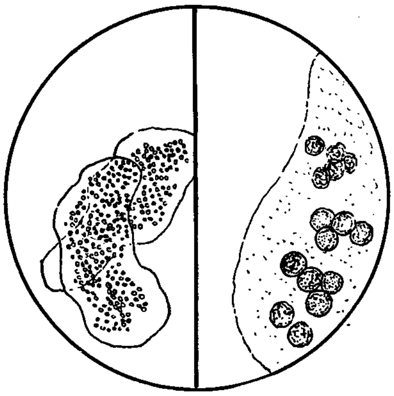
Fresh-Water Algae

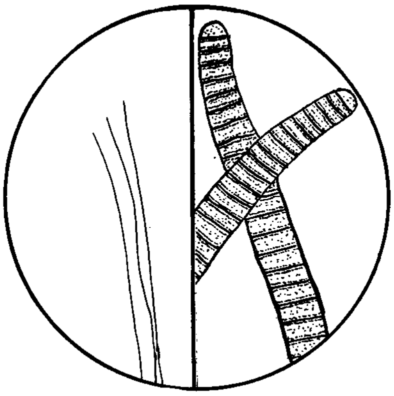
By E. LAURENCE PALMER

This is the sixty-ninth in NATURE MAGAZINE'S *series of educational inserts.*

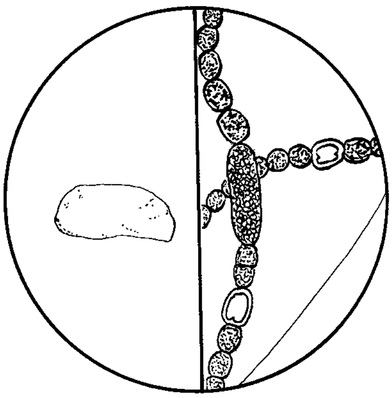
NOTE: In the illustrations, the algae in the left-hand semi-circles are of low magnification, the right-hand of high magnification.



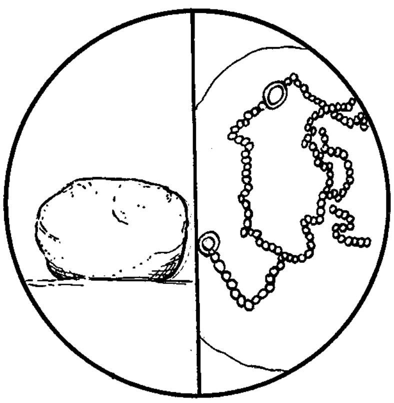
MICROCYSTIS



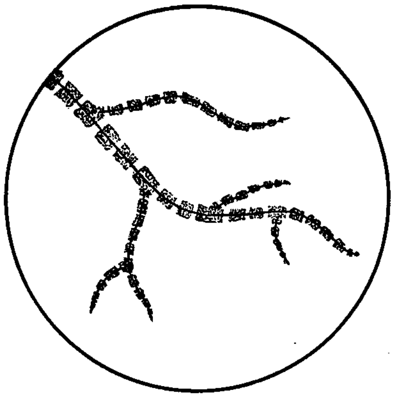
OSCILLATORIA



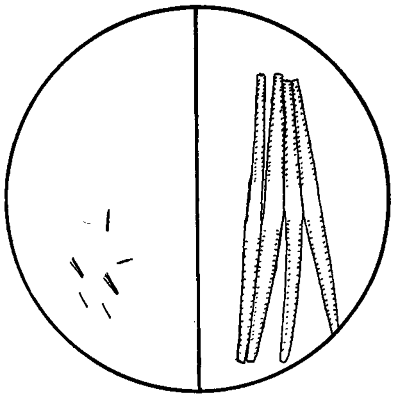
ANABAENA



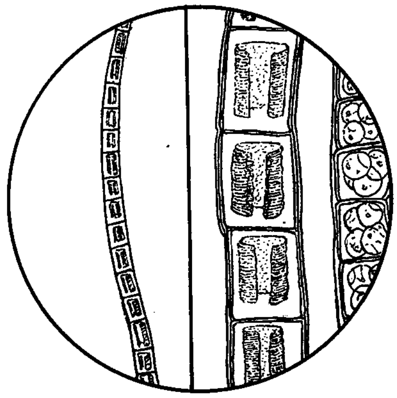
NOSTOC



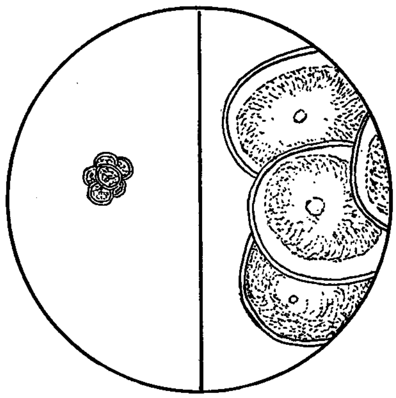
BATRACHOSPERMUM



FRAGILARIA



ULOTHRIX



PROTOCOCCUS

AN EARLIER insert of this series dealt with sea-weeds, algae of salt-water. So it now seems appropriate to have a fresh-water counterpart to that marine unit, even though fresh-water algae cannot match in size their salt-water cousins. So close is the relationship between fresh-water and salt-water algae in the average mind, however, that I have heard Iowans from the middle of the continent refer to the algae in their streams as "sea-weeds."

Where and When Algae May Be Found: Algae may be found on the surface of rocks in running water. One might almost say that wherever water may be found algae may be found, but this is not so. They may even be found where there is no water. Sulphur springs, salt springs, hot springs, hard-water springs, bogs, lakes, streams, soil, plants, animals, rocks, clothing — all may harbor fresh-water algae at times. Of course, springs may be too hot; lakes too deep; rocks too dry to permit algae to flourish, but living algae have been found many feet underground, more than 150 feet under water, and in such apparently dessicated plants as some of the lichens. They may be found on glaciers, under ice, on snow banks in widely separated parts of the world. They may give color to the landscape, making it green, yellow, brown or even red. In short, it would be difficult to find outdoors, at any time, a time or place where algae are not to be found. Their presence may not be readily apparent, but, given time, it could easily be demonstrated.

Give one alga or another a little time, a little water, some light and a suitable temperature, and it can thrive almost anywhere. Their simple physiologic needs no doubt account in part for their ubiquitous, cosmopolitan nature. Without their presence there would be few living things in our waterways, and yet the presence of some of them in waterways is definitely contrary to the needs of some living things. You may think that you have never seen these plants, but I doubt if any person who is not blind has failed to see fresh-water algae at some time or other.

The Role of Fresh-water Algae in the Biological Society: Fresh-water algae are the basic food organisms in many waterways. As free-floating, or partly or wholly submerged plants, they may make up a major and certainly an important part of plankton. The animal part of plankton could not survive without the fresh-water algae on which they feed, and most fish feed on plankton organisms at some time in their lives.

Joined with certain fungi, some algae form a unique society that we call lichens. The algae use light and water to make food that sustains the alga and its captor fungus. The fungous plant supplies support for the alga, and provides water to some extent.

Some of the larger fresh-water algae provide a direct food supply for fishes and even for such large mammals as deer, moose and other plant-eating mammals. Most of the larger algae provide superior shelter and food for the smaller animals that provide food for such common game fishes as trout and bass.

The production of algae may be so stupendous at times that their numbers blot out sunlight normally available to organisms living deeper in the water. This may be dangerous, or it may be beneficial, depending on what is desired. It has been estimated that, in one year, as much as 200,000 tons of plankton pass the city of Havana on the Illinois River, and of this a goodly proportion are undoubtedly algae, with the remaining portion living off the algae.

Algae and Physiography: It might seem strange to think of algae as moulders of the surface of the earth, yet they do play such a role. Stand by almost any stream, or feel the bottom of the stream, and you will see or feel masses of ooze or jelly. This jelly is probably muddy because it has taken silt from the water and held it in position. A continuation of this process would obviously build up the sediments on the bottom of the waterway more rapidly than would otherwise be the case. The absence of such oozes may well permit more rapid erosion of the looser soil particles beneath. So it would seem that these plants may build and hold, or permit the washing away, of soil particles. It is by these processes that the face of our earth is carved to a considerable extent.

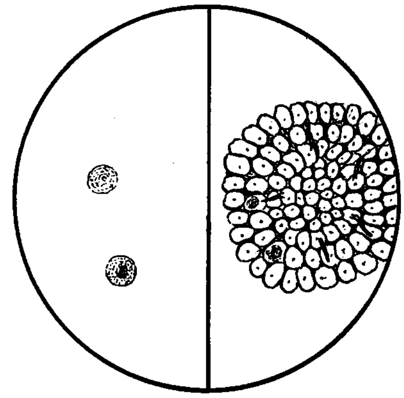
Of course, the support these organisms give to plants and animals also makes them in part responsible for the changes these creatures contribute to the landscape.

Algae, through various physiological processes, make unique contributions to the earth on which they live. Some, like some of the nostocs, are capable of fixing atmospheric nitrogen. The significance of this must be far-reaching. Some, like *Chara* and many simpler algae, have the ability to take lime out of water, thus softening the water but contributing to the marl on the bottom. Some are associated with sulphur deposits and some with salt.

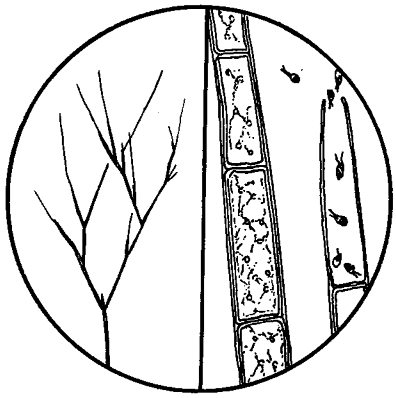
Possibly one of the most spectacular and important, and yet least recognized, relationships with the inorganic field is the role algae like the diatoms have in building up deposits of silica. On our west coast there are deposits of diatomaceous earths more than 700 feet deep, and these serve important economic roles, as you may see in the chart material under that title.

It is fortunate for us that the bottoms of many waterways are covered with the oozes caused by algae. Even the fine particles of silica left by diatoms may, with or without the oozes, serve as a screen that helps filter the water that goes into the earth beneath. Without such filtering much of the water that comes to the surface in springs might be unfit for human consumption. The materials filtered out of the water, of course, remain to build up land and change the face of the earth, at least to a slight degree.

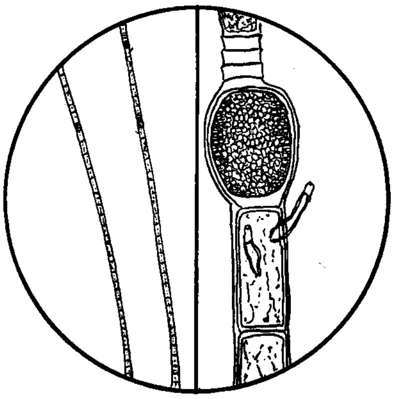
Man recognizes this role of diatomaceous deposits in filtering, and the commercial filters maintained by municipal water plants use diatomaceous earths in part for this process. Some kinds of filter paper used in chemical laboratories are made in part of filaments of algae reinforced for strength with other materials. Other examples of the economic importance of these diatoms may be found in the chart sec-



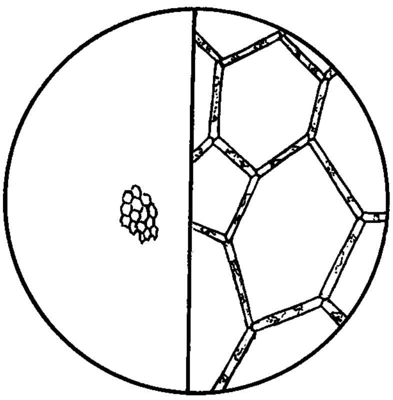
COLEOCHAETE



CLADOPHORA



OEDOGONIUM



HYDRODICTYON

tion of this special insert.

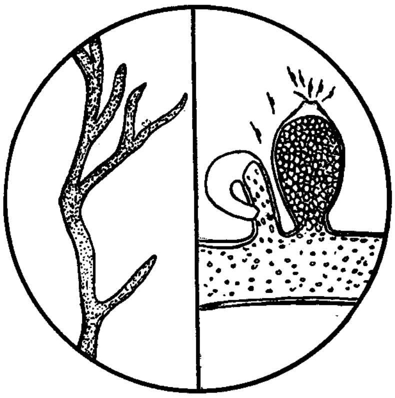
All students of natural history have been taught of the role of lichens in wearing away rock and in making from such rocks the initial soils from which our garden soils eventually develop. In thinking of this we must recognize that lichens are in part algae, and so algae do serve an important role in etching the hardest rock and thus gradually changing the topography of the earth.

The Economic Importance of Fresh-water Algae: It is not likely that men will cultivate fresh-water algae for commercial purposes to the extent they will marine algae, and yet there are those who will argue this point. Marine algae yield great quantities of potash and other valuable minerals, which we are not likely to recover from fresh-water algae.

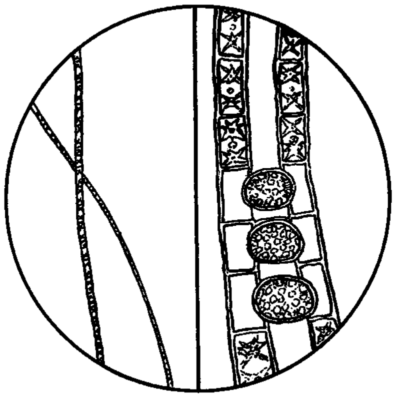
We have suggested the positive role of algae of fresh waters as the basic food for fish. There is a negative role that is important. Much of the difficulty of producing pure water for human consumption involves the control of algae. These algae, which may be found abundantly in drinking water, may affect the taste, odor and even the safety of the water for human use. The tabular matter gives you some understanding, for example, of how important the alga *Microcystis* may be in this connection. We could have added many others, particularly if we considered the realm of those organisms that are claimed by both the botanists and the zoologists. Some biologists list *Synura* as a plant in the algal group. It makes water smell like ripe cucumbers, and gives it a spicy taste due to aromatic oils that are freed. These oils are so strong that one can detect a dilution of one part in 25 million parts of water.

The fouling of swimming pools is a problem in some communities. This may be due to the presence of *Synura*, *Dinobryon* or *Uroglena*, all of which may be claimed both by the zoologist and the botanist. Fortunately some algae serve an equally important function in purifying the waters defiled by their relatives.

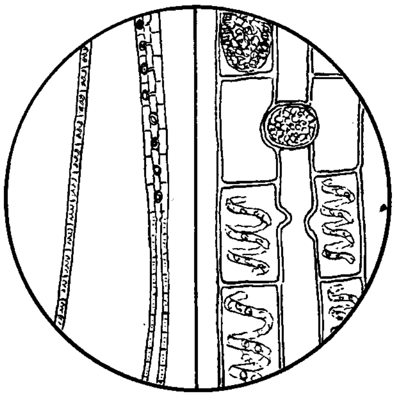
In these days of wars, famine and distress for great sections of the world's population, we are concerned about food. Food has been a problem ever since life appeared on the earth, and it



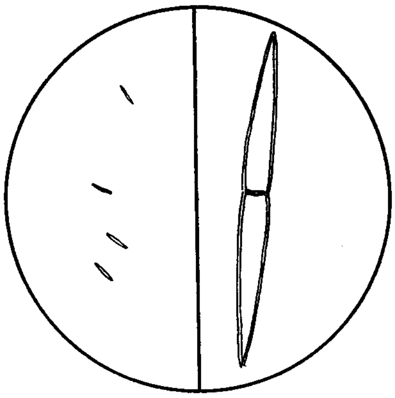
VAUCHERIA



ZYGNEMA



SPIROGYRA



CLOSTERIUM

will probably remain so to the end. Even today demagogues and others blithely ignore this situation, and continue to dissipate the food reserves they may have. Such policies cannot go on forever.

We know that it is inefficient to eat meat from animals that must convert plants inefficiently into food for us. We may, because of this, eventually come to a vegetarian economy, or we must have wars and diseases to wipe out proportionately large units of our population; or the demand to limit populations, voluntarily or arbitrarily, gains favor. The next step after we had established an economy based on plants might well find us at a point where we depended more than ever on such simple plants as the fresh-water algae and yeasts that get their nourishment from the algae. You and I will not be here to see such a state of affairs, but it is just as logical to assume this will be the closing chapter of man's life on the earth as it is to accept some of the chapters that have been written about our earlier experiences on this terrestrial globe. There have been blatant, calamity-howling magazine articles written outlining the possibilities of such a future based on a lower-plant economy. There is enough logic in the arguments advanced for us to feel that unless history changes its trends this will be the story. When that time comes someone will study, manage and know our fresh water algae as well as we now know pigs, sheep, cattle, wheat and green apples.

The Management of Fresh-water Algae: Since fresh-water algae are of importance to man it is only natural that he has found ways to encourage and to discourage them, as his needs indicate. To a considerable extent this is by chemical means, but it may be otherwise.

I shall always remember the deep blueness of the pools in front of a Mormon temple in Hawaii. At first I thought the color was something that added to the picture, which was most appealing. I soon recognized, however, that it was due to copper sulphate that had been added to the pool to prevent the development of mosquito larvae. Copper sulphate is one of the chemicals most commonly used in controlling algae in lakes and (*Continued on page* 32)

NAME SCIENTIFIC NAME	MICROCYSTIS	OSCILLATORIA	ANABAENA	NOSTOC
DESCRIPTION	Free-floating masses of jelly, of irregular size and shape, enclosing colored cells that are not arranged in strings as in *Nostoc* and *Anabaena.* The cells are usually more crowded in the jelly envelope than is the case in *Nostoc* and *Anabaena.* Some of the cells may show false vacuoles.	Masses of fine, blue-green, hair-like colonies without the jelly covering described for *Nostoc* and *Anabaena.* Filaments are long and slender and unbranched. The cell units are frequently much wider than long like disks, but the colony may taper towards its free end. Color appears granular.	May appear in delicate mucous films or blobs, free floating or attached, usually clear and sometimes almost invisible. The colonies of cells show enlarged cells and clear cells in the necklace chain as described under *Nostoc.* Some *Anabaena* species are in plankton form.	Colonies may appear as firm, gelatinous balls to 2 feet long and 1 foot in diameter (*N. amplissimum*), but most species are in smaller colonies down to microscopic size. In gelatin are strings of almost spherical cells with occasional enlarged colorless cells. Colonies may be in solid, hollow, spherical, lobed, flattened or irregular masses of often muddy gelatin.
RANGE AND RELATIONSHIP	Class Myxophyceae. Order Chroococcales. Family Chroococcaceae. It has been said that classification here is based not on what characters are possessed by the plants but on the absence of those characters found in other closely related plants. There are more than 20 genera recognized in the family.	Class Myxophyceae. Order Hormogonales. Family Oscillatoriaceae. American genera in the family 11, and American species in the genus 30, or more. The strings or colonies of cells are called "trichomes," and in *Oscillatoria* lack the apparently empty cells "heterocysts" found in *Nostoc.*	Class Myxophyceae. Order Hormogonales. Family Nostocaceae. There are 7 genera in the U.S., and about 21 species in the U.S. The jelly envelope, if present in *Anabaena,* lacks definite form characteristic of *Nostoc,* and other differences are suggested under *Nostoc.*	Class Myxophyceae. Order Hormogonales. Family Nostocaceae. There are 6 American genera and over 20 species in the genus. *Nostoc* differs from *Anabaena* by having a firm gelatin with distorted strings of cells, while *Anabaena* has soft gelatin with rows of cells not commonly contorted.
REPRODUCTION	Reproduction is essentially by vegetative development and fracture of the colonies. There are 9 species of the genus to be found in the U. S., based in part on the shape of the cells. Apparently the reproductive process is reduced to its simplest elements.	Reproduction is largely vegetative, by the fracture of colonies. There are no "akinetes" or large resting cells such as are found in *Nostoc* and *Anabaena.* The cells acting as resting and reproductive cells are known as "hormogones," or a hormogone may be considered as a series of cells.	Reproduction is by fracture of colonies and essentially the same as is described for *Nostoc,* though the reproductive resting akinetes are conspicuously larger in some *Anabaenas* than in *Nostoc,* in proportion to other cells of the colony.	Reproduction is simply by cell division and breaking up of colonies, or by unusually long cells (akinetes), which develop only when the colony has reached maturity. The akinetes may be a resting stage and are adjacent to one of the clear cells heterocyst in the necklace chain of cells (trichomes).
ECOLOGY	*Microcystis* is essentially a plankton genus. It may cause "water blooms" to develop in hard water lakes and ponds. It may produce poisonous substances in sufficient quantities to be dangerous, but this is not necessarily so, and its presence in water is not always a menace.	The bottoms of streams, springs and shallow ponds may be covered with mats of this blue-green alga. *Oscillatoria* can survive in stagnant, putrid water, and its presence may be an index of heavy pollution. One species, *O. prolifica,* gives a red color to lakes in which it exists in plankton form.	There are 2 parasitic species, one living in leaves of *Azolla.* About half of the species are in plankton form including *A. spiroides, A. circinalis* and *A. flos-aquae.* Pond and ditch attached species include *A. catenula, A. inaequalis, A. oscillarioides* and *A. variabilis.*	Colonies may develop on small amount of soil covered with abundance of water, as an occupant of root tubercle on cycad, as a part of a lichen, at depth of over 60 feet in lakes and over 3 feet in earth. Some favor deep still water; others, rapidly flowing water. *Some may use atmospheric nitrogen.*
ECONOMY	In heavy concentrations *Microcystis* has been known to be fatal to live stock that drank water containing it. It has killed cattle and sheep and, under laboratory conditions and intense concentration, has killed guinea pigs and rabbits in from 12 to 15 minutes. It is obviously a dangerous water pollutant needing control.	May serve as a water purifier and certainly as evidence of pollution in some cases. Some species are found in damp soil, on exposed rocks, in mud. Species differences not well defined but may depend on shape of cells, straightness of strings, nature of ends of colonies, and so on.	In Lake Erie in July and August enormous quantities of *Anabaena* are produced in the shallow shore waters, making the water murky and generally unsightly but harmless. It may be a pollutant of drinking water supplies and as such an annoyance if not a serious danger.	Of considerable importance as a water pollutant. Gelatin takes silt out of muddy water and helps build soil. Has symbiotic relation with the horned liverwort *Anthoceros.* In South America the gelatin is boiled with garden vegetables to add flavor to the mixture. *N. commune* a common terrestrial species.

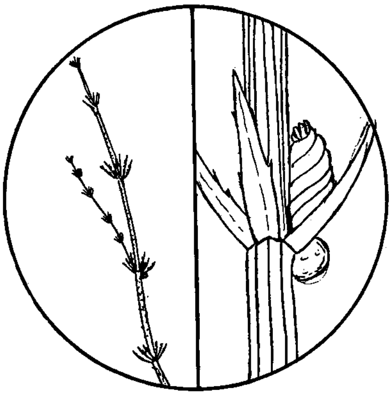
Batrachospermum	A Diatom *Fragilaria*	Ulothrix	Pleurococcus or Protococcus	Coleochaete
Like long-branching, flexible strings with finer branching bunched branches in whorls, giving the impression of a string of tufted branches that grows smaller towards the tip. The axis is a single row of large cells. Whole plant is blue-green, olive, or sometimes violet, and gelatinous. Some may be distinctly reddish.	Diatoms are so variable and numerous that we can here consider them collectively. They may form much of the slippery oozes that cover stones in waterways, but are essentially boxes of silica enclosing chromatophores or color bearers that can multiply with startling rapidity.	Usually found as bright green, slimy, unbranched strings, though under some conditions branches may form. Cells are flat ended cylinders with broad gelatinous sheaths with one nucleus and a girdle shaped color band that nearly or completely surrounds the interior. Cells often shorter than wide.	Appears usually as a green coloring for the bark of trees, moist earth and stones, or even in the bodies of lichens. Under microscope appears either as small green spheres if isolated, or as a mass of compacted green spheres often imbedded in particles of soil, fungus strands or bark tissue.	Appears like small roundish green plate of cells, with a few long "hairs," usually found on the underwater parts of cattails and arrowleaf that remain underwater through the year. Some species do not appear in the characteristic shield-shaped plate of cells but as branched structures.
Class Rhodophyceae. Order Nemalionales. Family Batrachospermaceae. There is but one genus in the family represented in America, and 10 species in the genus, though these are to be found collectively from border to border and coast to coast. The plants are more common than ordinarily suspected.	Class Bacillarieae. Order Pennales. Family Fragilariaceae. In *Fragilaria* there is a mucous material connecting the cells into colonies. In some the valves are circular and in others (Pennales) they are usually bilaterally symmetrical. They are attached by mucus or freely floating plankton. Some are motile.	Class Chlorophyceae. Order Ulotrichales. Family Ulotrichaceae. Seven related genera in the U. S. Plants may be attached or free-floating and are usually at maximum development in early spring, with *U. zonata* a distinctly cold water early season species.	Class Chlorophyceae. Order Ulotrichales. Family Protococcaceae. Attempts to make different genera are based on obscure differences in the chloroplast or color-bearing part. Literature will show either name suggested in heading, but *Protococcus* is probably best to use.	Class Chlorophyceae. Order Ulotrichales. Family Coleochaetaceae. Widely distributed through the country with 3 genera in the U. S. and the many species varying from shields to cushions to branched structures. Some live within walls of other algae, or are supported by other algae.
Reproduction is by fragmentation of vegetative parts and by asexual spores produced, one to a cell, from ends of short lateral branches. Sexual reproduction is complicated, involving a fertilization process resulting in a fertilized egg that breaks away to form an intermediate juvenile stage.	Reproduction is largely by cell division, but there is a reproduction by production of asexual spores, and another through production of microspores and other spores that apparently duplicate the usual sexual reproduction pattern at least in essence. Rapid reproduction is mostly vegetative.	Reproduction by cell division, fracture of filaments. Cells may yield 4 motile spores that become free and start new plants or may yield 2, 4, 8, 16 or 32 spores with 4 swimmer hairs that swarm for a day or so. Smaller spores swarm 2-6 days if temperature is below 10°C.	Reproduction by simple cell division. There are no motile spores or sex organs, the plant getting its worldwide distribution by taking to the air and being blown about. Commonly cells may remain together until they can free selves and be blown about.	Reproduction largely by zoospores produced one to a cell and each bearing 2 swimmers. These may be produced at any time of the year, but in spring all cells of an old plant may produce zoospores ending the life of the old plant. Sexual reproduction in most species by union of different sized gametes.
Plants have been found in Lake Ontario to depth of over 150 feet. Plants in shade and in deep water are reddish or deep violet, rather than the olive green of the plants grown in better illumination. The color of the plants can be changed by varying the nature of the light.	Serve a role in water purification and possibly, in some cases, as a pollutant. The silica cell walls do not disintegrate easily and may accumulate in enormous quantities as diatomaceous earths. This is a general observation and not limited to the genus listed above. Deposits 700 feet deep known.	Sexual spores produced in numbers of 8, 16, 32 or 64 pair and pairs remain motile. Fertilized pair yield 4-16 daughter cells that start new plants. Some species that are abundant in spring are uncommon in summer and abundant again in the fall. Others appear only in limited seasons.	Cells have abnormal ability to take up water and so they may add a quick green to bark after a rain following a drought. Some may survive temperatures of 40°C. below zero. In lichens the plants, through ability to make sugars and starch with help of light and water, make the association successful.	Sexual reproduction is so complicated and unusual that plant is popular with botanists because of its behavior. In winter the plant may survive as it is or through reddish-brown, sexually produced, fruit-like bodies near margin of plant, which produce mobile zoospores that take over with the spring.
This "red alga" of fresh waters is representative of the group, which is so abundant in the seas. It apparently has no great economic significance and has not found its way in common literature as a food for fish or wildlife. It is found in springs, brooks and cool lakes and streams, usually in shade.	Serves superior role as shelter for aquatic insects and as food for fishes that eat the ooze and the insects as well. Polishing powders are made from the silica shells. In some cases, diatoms are used in making explosives, in filtering liquids, in strengthening cement and in tooth pastes.	May act as a water pollutant or as a water purifier, depending in part on abundance. May also serve as food for insects, fishes and other animals. Obviously a relatively primitive alga.	*Protococcus viridis* has been considered the world's commonest, most widely distributed alga. Legend about green north sides of trees is explained by its abundance in the damp, shady side of trees as against the dry sunny side. Use as direction finder not wholly dependable, of course.	Probably of no economic importance and of little biological significance except for its reproductive story. The plants are not large enough for substantial food for aquatic organisms, nor can they well be important in pollution or as food for man. They do not injure plants on which they grow.

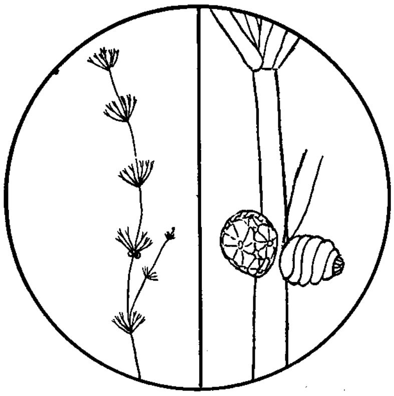
NAME SCIENTIFIC NAME	CLADOPHORA	OEDOGONIUM	*WATER NET* HYDRODICTYON	VAUCHERIA
DESCRIPTION	Usually attached, branched strings of cells, each of which is rarely more than 18 times its width, but is usually conspicuously longer than wide. Length may be a number of feet and plant feels harsh rather than slimy and lacks the luster of some other filamentous forms.	Relatively large, coarse, unbranched strings of cells that are usually elongate cylinders containing a spotted green sheet (chloroplast) that encloses remainder of cell contents. There is a single large nucleus just within the chloroplast. Reproductive cells conspicuous.	Small, fine, green nets easily identified with the naked eye, floating in masses in relatively still water with the sides of a hole in the net usually composed of 5 or 6 cells but varying from 3 to 10. Nuclei appear in multiples of 2, and adult cells have large free space and varied chloroplast.	Common as a green felt on flower pots in green houses, or as floating or attached mass of branching strings which do not have crosswalls. Mats are dense and weak and usually pale yellowish-green and slimy. There are many nuclei and the color-bearing bodies are many and toward outside.
RANGE AND RELATIONSHIP	Class Chlorophyceae. Order Ulotrichales. Family Cladophoraceae. May be found in Lake Ontario to depth of 150 feet (*C. profunda*). Two genera are represented by branched and 2 by unbranched filamentous forms. There are 7 species of *Cladophora* found in western Great Lakes area.	Class Chlorophyceae. Order Oedogoniales. Family Oedogoniaceae. We have the one family in the order. The three genera in the family include the unbranched *Oedogonium*, the bristle-branched *Bulbochaete*, and the bristleless, branched *Oedocladium*.	Class Chlorophyceae. Order Chlorococcales. Family Hydrodictyaceae. There are 4 genera in the family in U. S. and 2 species in this genus, *H. reticulatum*, the commoner, making nets up to over 1 foot long, and the brittle *H. indicum* of the West with 1-inch cells, though identification as *indicum* not established.	Class Chlorophyceae. Order Siphonales. Family Vaucheriaceae. There are 7 groups of the genus of which 4 are found in U. S. The differences being based largely on the shape of the sperm-producing organ. Reproductive organs are separated from plant body by cell walls naturally.
REPRODUCTION	Vegetative reproduction by fracture of filaments and division of cells. Some cells may produce many free-swimming spores that can develop new threads. Still others may produce free-swimming spores that unite in pairs and develop new threads. Resultant fertilized gametes are outside parent cell.	Vegetative reproduction by simple cell division. Some cells free motile cells that establish new plants without mating. Others free many small male motile cells that fertilize egg that occupies single cell, or develop dwarf male plants that develop sperms that fertilize the egg.	Vegetative reproduction by fracture of nets. At daybreak or early morning cells may free motile zoospores that form new net in old, whose walls then disintegrate and net enlarges. Sexual reproduction by motile cells that unite outside parent cell and free from 50 to 100 zoospores after rest.	Vegetative reproduction by breaking of strands. Sexual reproduction by 2 adjacent protuberances the female bearing one egg and the curved male yielding many small motile sperms that fertilize the egg. Fertilized egg develops thick wall and may go into resting stage of many months.
ECOLOGY	Some, like *C. glomerata*, are perennial, while others have different seasonal habits. At least one is to be found as a component part of a lichen. Most are common, recognized as long-branching strings attached to stones at the bottom of streams. Chloroplast may be a sheet, net or other type the length of the cell.	Transferring plant from natural solution to distilled water or vice versa stimulate spore production. Plants stimulated to activity by being kept in darkness and then brought to light. Sperms live up to 2 hours and produced most abundantly 12 M. to 4 A.M. and early P.M.	Probably not of importance economically. Must be some association between light and reproduction because of the pattern followed. The zoospores formed in the sexual pattern form net within their original cell before being completely freed by disintegration of cell wall.	*V. hamata* is a spring annual. Some species found in garden soil, some on stones under ice, some in thin mats at bottom of shallow springs. Sperm swarming period is short, and in *V. terrestris* is lacking. Bringing land forms into water, aquatic forms into darkness induces formation of swimmers.
ECONOMY	May serve to help aerate water, as food for insects, fish and other aquatic animals and may contribute to the slipperiness of stream bottoms. Provides shelter for some small water animals and anchorage for others. Some may appear as green balls around bubbles in great numbers on lake shores.	Species are spring, summer or autumn annuals. Iodine causes blue color in cells, indicating presence of starch. In India the plants are dried and sold as food. May be a pollutant of water and serve as food for insects that feed fishes or directly as fish food.	Of more interest to botanists and general naturalists than to economic minded folk. The nets may be eaten by aquatic animals such as insects, fishes, ducks and other animals. The nets are always intriguing, usually because so few persons notice them.	Some forms moved from running water to still water will respond by producing swimming spores. Sperms are usually freed shortly before daybreak. In some the male or female sex organs are borne on separate stalks but usually near each other. Zoospores need not go through fertilization.

ZYGNEMA	SPIROGYRA	DESMIDS *Closterium*	*STONEWORT* CHARA	*STONECROP* NITELLA
Unbranched, green, slimy strings of cells free-floating or attached at one end. Cells varying from equal in length to width to many times as long as wide. Each cell contains two star-shaped green chloroplasts that lie either side of the nucleus and have conspicuous centers.	Usually bright green, slimy, unbranched strings of cells that are longer than wide and contain 1 to 12 green spiral bands (chloroplast) together with a nucleus that may not be easily visible under a microscope under ordinary conditions. Hand lens may show spiral chloroplast sometimes.	Microscopic and of almost all imaginable shapes, but all with cell walls with vertical pores through them. Most are unicellular with one chloroplast to a section. Closterium resembles a slender, two-pointed horn with an obvious division across the middle, or like two slender cones placed together at their bases.	With stems 8 or more inches long, bearing double whorls of leaf-like structures with 8 to 10 leaves at a joint, coarse, usually brash because of heavy encrustation with lime. The stem covered by layer of long cells extending from one joint to the next, or broken at intervals by smaller cells.	Usually slender, smooth, erect, attached plants with whorls of "leaves" at joints with the sections between joints 2-4 times the length of the leaves or branches. Stems not covered with layer of long slender cells as in *Chara*. Branches at joints may be divided or undivided and are to 8 at a joint.
Class Chlorophyceae. Order Zygnematales. Family Zygnemataceae. There are about 14 species of the genus to be found in the United States, usually associated with *Spirogyra*, but in southern California *Zygnema* is usually the more common. We have 9 genera representing the family.	Class Chlorophyceae. Order Zygnematales. Family Zygnemataceae. In the U. S. there are over 65 species of Spirogyra and at least 9 genera in the family Zygnemataceae in the U. S. Reproducing strands show H-shaped cells connecting two parallel strands with some empty cells.	Class Chlorophyceae. Order Zygnematales. Family Desmidaceae. Differences in genera and species are based entirely on the shape and structure of the vegetative cells. Symmetry seems to be the pattern on which desmids are built, in spite of their obvious complexity in details.	Class Chlorophyceae. Order Charales. Family Characeae. Much controversy centers on the place of these plants in the plant kingdom. The related *Nitella* lacks the cell covering on the stems described above. Does best in hard water environment and may sometimes be taken as index of alkalinity.	Class Chlorophyceae (or Charophyceae according to some). Order Charales. Family Characeae. There is but one family in the order and 2 genera in the family. Some authors have proposed that the plants are a distinct class of algae belonging near the mosses because of the character of the sperms.
Vegetative reproduction by cell division, each cell getting a chloroplast, which then divides, or by breaking of filaments. In some species sexual reproduction effected by joining of cell contents of pairs of cells in parallel-lying filaments forming colored resting cell.	Vegetative reproduction by simple cell division and filament fracture. Sexual reproduction by joining of contents of two cells to form a "zygote," which may act as a resting stage. Species differ in time of maturity and reproduction not so much as environmental but maturity causes.	Reproduction is usually by simple cell division, or sometimes by production of spores. Sexual reproduction takes place following the joining of two free individuals, the union of their protoplasm into a common mass, which eventually develops into new units.	Reproduces by fracture of the stem or by a sexual reproduction associated with vase-like or long egg-like structures borne in the leaf axils. Cells bearing male or female elements are found on a single plant and may be visible to naked eye. Sperms borne in long, coiled, slender threads with crosswalls.	Reproduction is by fracture of the vegetative parts and by sexual processes. The egg bearing structure in *Chara* is capped by 5 cells; in *Nitella*, by 10 cells. The egg-bearing cells are enclosed by a twisted sheath of cells and may become dark brown when mature and be easily seen with the naked eye.
Lateral joining of cells due to heredity not to environment. *Z. stellinum, Z. leiospermum, Z. insigne* are spring annuals and in permanent ponds *Z. pectinatum* is a perennial. There is one terrestrial species, *Z. peliosporum*. In some species one cell loses content to another.	Spring annuals include *S. catenaeformis* and *S. protecta;* summer annuals *S. nitida, S. setiformis, S. irregularis* and *S. ellipsospora*. Iodine may cause blue spots in cells indicating starch presence. Oils also may be recognized as well as clear spots.	At their best in waters with a pH of 5 to 6. Desmids may be observed in aquaria making their way towards the lighted side by means of a series of jerks, probably in part due to secretions of gelatinous materials. The vacuole at the end of each cell in *Closterium* contains one or more granules of gypsum as balancers.	Definitely associated with presence of lime. When drying on a boat or shore gives off characteristic odor. Often found over marl bottoms, and may contribute to the deposition of lime and the build-up of a marl deposit. Listed as food for moose, deer, waterfowl in many references.	*Nitella* is much more slender and fragile than *Chara*. Both provide shelter and are rich producers of fish food, particularly for trout and bass. Both have a softening effect on water taking from it lime and carbon dioxide and assisting in the production of marl. Has characteristic odor.
A pollutant like *Spirogyra* with most of the general qualities of that genus. It is eaten by insects and by fish and even by squirrels and other mammals on occasion. Records of use as food by man seem to be lacking, but it would be only incidental and unusual, anyway.	A water pollutant either found free-floating or attached. Normal length of vegetative cycle is variable. Has some value as fish food and as food for insects that are fish food. In India some species are collected, dried and sold for use as human food.	Of little if any economic importance. May make up a portion of plankton in a waterway, and plankton has food value for organisms that may have food value for man. Of primary interest to botanists and a great challenge to some microphotographers who become intrigued with the beauty of the symmetry of the plants.	Aside from value to wildlife as food and shelter for smaller food animals, it has been demonstrated with some success that mosquito larvae growing in water that supports *Chara* in abundance in small pools do not reach maturity. Plant may serve thus as a check on mosquito populations at times. See *Nitella*.	Economic importance much like that of *Chara* and as suggested above may be associated with fish. Some waterfowl feed on these plants, possibly because they usually abound in small animals which with the plants give a mixed and useful diet.

(*Continued from page* 27)
streams. When stream managers wish to start fresh with the organisms in a body of water they frequently kill off the existing population with copper sulphate, and start all over again as soon as it has been washed away.

Modern pond management designed to produce fish for the farmer's table is essentially a matter of managing fresh-water algae. A plankton population is maintained at such a level that it blots the light from the deeper waters and prevents the development of larger water plants, which might clog the pond and hinder the activities of fish. This is a fine example of exact management that has been developed in recent years, and is each year being improved somewhat. This management is largely effected through so feeding the plankton organisms as to maintain the desired balance between plants and animals and the desired population in the desired places.


CHARA


NITELLA

How Fresh-water Algae Live: The average high school student who has had a basic course in biology has been exposed to the life history of algae, possibly much to his annoyance. Of course, freshwater algae must have the basic conditions that maintain life. They must have water, oxygen, light, suitable temperature and suitable chemical environment. With these we can hardly be concerned here. We can point out the variations that are obvious in the prosperity of algae in regions of different light intensity and in waters of different temperature. We can point out that, even in garden soils, conditions may be suitable for the growth of some algae, and that their presence there may add to the economy of those soils.

Given suitable physical conditions, our algae will grow. Growth varies with the groups, of course. To all, development of the vegetative body is important. Some of the simpler algae do not develop beyond this. The higher algae, however, may develop special cells that yield special motile spores, which can move about at will and establish new plants. This is a quick way for a species to occupy suitable territory, or to recover from diminution. Still further, we have the sexual reproductive technique, which makes the eyes of the academic botanist gleam and which really does provide a most interesting vehicle for appreciating the evolution of the reproductive process in any organism. The mental discipline involved in mastering this story is not appreciated by the beginning botanist, but never fails to intrigue the one who has gained an understanding of the basic idea.

The details provided in the illustrations, in the tabular material in this insert, and in the average botany text should make it unnecessary for us to pursue this angle farther. At times the story has been touched on in Dr. Corrington's excellent articles dealing with the use of the microscope in biology.

Classification of Algae: Fresh-water algae, like other organisms, may be classified according to their relationships, according to their ecological nature, according to their economic importance, and otherwise.

Botanists generally recognize seasonal groups as follows:

Winter annuals may begin development in autumn and continue developing from November to April, reaching a reproductive climax in March and April. Examples are *Vaucheria sessilis* and *Spirogyra tenuissima*. These may be found when this insert is first published.

Summer annuals germinate in spring and reach their greatest degree of prosperity in July and August. They produce asexual spores most abundantly in spring and summer, and sexual spores most abundantly in August and September. Examples may be found in the chart section.

Autumn annuals begin development in late spring and reach their maximum abundance in late autumn.

Perennials, as the name implies, may be found in full vegetation at almost any time of the year. They usually are at their best in sexual reproduction in May and June.

Ephemerals are those species that may complete their vegetative cycles in a few days or weeks, and may do this at any time of the year when the physiological conditions suit their demands.

Classifications based on hereditary relationships provide a field day for the botanists working in this field. It used to be simple to classify the algae as blue-green, green, brown and red. Our insert on sea-weeds introduced you to many red algae and brown algae, and to some green algae, because these groups are most conspicuously represented in the sea. This unit on fresh-water algae omits consideration of the brown algae because the group is essentially marine. It includes one red alga because at times some of these species may be conspicuous and may supplant other algae. This leaves us free to emphasize what we formerly considered as the blue-green and the green algae. I have on my desk beside me six books on algae published in the last few decades, but with little agreement as to what the major groups may be. The order in which these are considered in the books varies and is radically different from the order in which they were considered when I was a student, and, later, a college professor of botany. I have tried to recognize a conservative classification here and will leave it to you to get it from the second section in each of the life histories given under the head of relationships.