THOSE MARVELOUS, MYRIAD DIATOMS
ARTICLE AND PHOTOGRAPHS BY RICHARD B. HOOVER

Such perfect architects, these diatoms. They spin themselves intricate houses of opal in the sea. Glittering pinwheels, spirals, stars and chandeliers! More than twenty-five thousand species of diatoms, and no shell the same. Each a living jewel. My microscope becomes a kaleidoscope.

Diatoms are so exquisite it is hard to believe they are also enormously important. They are, one could argue, the most vital plans on earth. They bob, drift, and sometimes glide through most of the waters of the world in incredible numbers. Just one liter of seawater may contain as many as ten million of these one-celled specks of algae-the primary foodstuff of the sea.

Even land-dwelling creatures, including man, are in their debt, for diatoms that teem in the upper few meters of the oceans produce, through photosynthesis, much of the oxygen we breathe.

By profession I explore the universe as an X-ray astronomer. About a decade ago I discovered a collection of these brilliant little plants my bride-to-be had inherited from her great-grandfather, an early diatomist named Cornelius Onderdonk. Now my off-hours belong to diatoms. They enchant and intrigue me. I have photographed thousands of them, and I travel the world to collect new specimens.

These golden-brown algae thrive wherever there is light, water, carbon dioxide, and the necessary nutrients. I find them in cold Rocky Mountain streams, in thermal springs in Arkansas, in polluted pools and roadside ditches. Marine species often form a brown coating on Arctic ice floes.

Not all diatoms are aquatic. Under moist conditions, some live in topsoil, or attached to moss, tree trunks, or even brick walls. Diatoms can endure lengthy droughts. Recently, while studying the famous Van Heurck diatom collection in Antwerp, Belgium, I added water to diatoms that had been dried on paper in 1834. I was astounded when they began to swim - revived after nearly 150 years in slumber.

Diatoms vary widely in size, but the very largest measure only a millimeter across. To the naked eye, their appearance is usually unimpressive. In the Australian desert I once spotted a brownish layer of diatoms floating in a salty pool.

"Are you sure they're diatoms and not just something left behind by a passing emu?" chuckled my naturalist friend John Ison. I scooped up a sample, and later at John's bungalow my microscope convinced him. Hundreds of graceful S-shaped Pleurosigma glided past slender rods of Synedra.

Diatoms are the most abundant kind of phytoplankton, and colder oceans support the greatest numbers. Some dwell near the seabed, and will even burrow into the mud. Most float near the surface, however, to absorb sunlight.

One Species Has Built-in Tidal Clock

Photographing diatoms, I soon learned to distinguish two basic forms. One group is often called the Centrales. They have markings - rows of pores or spines - that radiate with perfect symmetry. Most Centrales are oceangoing and are commonly wheel-shaped. They are typically bobbers, drifting near the surface, basking in sunlight and letting nutrients come to them.

[Caption for photograph] Diatom graveyard gives man agents that filter, polish, insulate - and even help save his life by supplying the reflective sparkle in roadway-lane striping. They do all this through trillions of their lifeless shells, called diatomaceous earth. Kelly Phelps holds 25 pounds mined at Lompoc, California.

Then there are the Pennales. These tend to be elongated, their markings in bilateral rows. Most live in freshwater streams, swamps, or ditches, or on the bottoms of shallow regions of oceans and estuaries. Many Pennales can move about by themselves. On tidal sand flats of Cape Cod, a species called Hantzschia virgata demonstrates their locomotion elegantly. When the tide is in, the Hantzchia lie buried in the sand. Marine biologist John Palmer has found that just after the tide goes out the diatoms glide to the surface for a sunbath, turning the sand flats a golden brown.]

Remarkably, the Hantzschia know precisely when to burrow back into the sand. They retreat moments before the return of the tide, which could wash them out to sea. Even after weeks in a laboratory, under constant light, they continue to dig in and out of the sand with such accurate timing that Dr. Palmer can use them as tide tables.

Still, to me the diatoms' most impressive skills are a shell builders. They are alchemists, changing dissolved silicon into a silica almost identical to the gemstone opal.

The glassy shells are of incredibly varied and beautiful architecture, some are riddled with pores, which both lighten the structure and permit the intake of nutrients and the exchange of gases. In their teeming trillions, diatoms produce oxygen far in excess of their own needs, making an enormous contribution to our atmosphere.

They also play a vital role in the food chain. There is probably more available organic matter - in other words - food - contained in the world's diatoms than any other living thing. Sometimes called the grasses of the sea, they are the main fodder for the little vegetarian animals, such as copepods and shrimplike krill, that make up the zooplankton community. These are typically consumed by small fish such as herring, which in turn become food for larger species.

It requires several hundred billion diatoms to feed a humpback whale for just a few hours. Marine biologist N. J. Berrill estimates that it takes half a ton of diatoms to make a pound of seal. A pound of killer whale, a predator of seals, would require five tons of diatoms.

Even the diatoms' own food is of great importance to mankind. The food reserves that they produce through photosynthesis are stored within their cells as minute globules of oil. As ancient diatoms died, they were buried by trillions beneath the sea. Geologic and biologic forces caused the globules to coalesce into pools that became petroleum. Much of the oil we use today probably began millions of years ago when the sun shone on diatoms drifting in prehistoric seas

Diatoms were discovered in 1702 by the early pioneer of miscroscopy Anton van Leeuwenhoek, who thought they were tiny animals. Not until the 19th century did biologists conclude that, since these organisms perform photosynthesis, they are plants.

Later in that century, as oceanographic vessels began dragging plankton nets through distant oceans, diatom collecting became a fashionable pursuit, and many names have been given to the same species.

To help clarify the resulting chaos in diatom classification, a German microscopist, J. D. Moller, spent 15 years mounting on a single slide 4,026 of the diatom species then recognized. At the Henri Van Heirck Museum in Antwerp, I was given the rare privilege of examining Moller's slide. That was like an art lover having a Rembrandt all to himself. Four thousand shells in a space the size of a postage stamp! I sat transfixed at the microscope all afternoon.

Mounting individual diatoms requires patience. I use a hog's eyelash on a toothpick mounted on a dowel rod attached to my microscope. I once asked one of the modern masters, the late G. Dallas Hanna, how long he thought it would take me to learn the mounting technique.

"It took me about six weeks," he said, "but you should be fairly proficient in three." I asked why I should learn faster. "Well, I started out in the Pribilof Islands off Alaska," he explained. "It was thirty below zero, and my hands shook a lot!"

One of the most fascinating sights a diatomist can observe under his microscope is reproduction. First, the two halves of the pillboxlike shell push apart. The diatom's nucleus then divides, and each new nucleus migrates into one of the half shells. The new diatoms then secrete a new inner half.

But a problem remains: The diatom formed from the inner half of the pillbox is slightly smaller, and when it divides, one of its offspring will be smaller still. Eventually the shells would become too small to house the necessary cell parts.

So, for most species, occasional sexual reproduction is essential. I have watched two Pennales come together and envelop themselves in a gelatinous material while they exchanged chromosomes. Later the fertilized protoplasm breaks out of its parent shell and develops into a new full-size diatom.

In Ten Days, a Billion Diatoms

Diatoms can reproduce at phenomenal rates, some even dividing every four to eight hours. These could become a billion in only ten days' time. Their immense blooms can change the ocean's color for hundreds of square kilometers. Eventually they deplete the available silicon and other nutrients. Greta numbers die and sink, carpeting the seafloor with a layer of diatomaceous ooze as deep as 300 meters. Some thirty million square kilometers of the northern Pacific and Antarctic sea bottoms are buried beneath mantles of dead diatoms. Over the aeons, as oceans rise and continents shift, this ooze fossilizes into rich deposits of diatomaceous earth, or diatomite.

Diatomaceous earth is mined in the American West for use in industry. Its light weight and a multitude of pores make diatomite an ideal filter. Beer and wine pass through its microscopic sieves. It is a fine abrasive, in demand for space-industry components, and a filler for paint, insecticides, and many other products.]

We reap a legacy from diatoms, living and dead. And it is not just that these inconspicuous pieces of glass-wrapped protoplasm make the earth a hospitable place on which to live. They fill our minds with wonder and teach us to look more closely.

I know now I can find perfect beauty any day in almost any mudhole, and in every new clump of brown slime, an adventure.

National Geographic, June 1979

[Text describing photos included in this article:]
Death comes in 12 hours after insects venture into diatomaceous earth. Their skins are pierced by sharp edges of the diatoms' siliceous shells, causing life's juices to flow out. Particles of this nonpolluting pest killer cover the rear of a cockroach (lower left) and are shown on an insect under extreme magnification (below) (End of photo description fork two photos)

(Photo description of one photo And A Chart Showing Asexual Reproduction)

Diatom Long Division
Asexual Reproduction of the Centrales species Stephanopyxis turris begins with a single diatom, its centered nucleus and interlocking shells.

The shells push apart as the nucleus splits, and now shells form on the inside of each original half.

One offspring (far left) is the same size as the original parent. But the smaller offspring (left) produces descendants successively smaller with each generation.

The shrinking process continues until a descendant is 60 to 80 percent smaller than the original parent. Then, if the right environmental conditions prevail, the sexual cycle begins. If conditions are not favorable, offspring continue to get smaller until reproduction becomes impossible and the line dies out.

SEXUAL REPRODUCTION. Diatoms entering the second reproductive cycle can be either male or female. Both sexes have elongated capsules tipped by shells connected by membranes. Within the female, three eggs are produced but only one lives. Within the male, sperm is produced within each of several components called spermatogonia.

The mating starts as mobile sperm from any of the spermatogonia reaches the mature female. Bending, she separates her membrane and makes the opening for penetration.

The fertilized egg swells into a globular shape containing a nucleus.

Within the embryo, shells develop around the nucleus and a cell forms.

The envelope ruptures, liberating the mature diatom which closely resembles the original parent; thus the cycle is complete. Like jeweled mandalas, 121 species of diatoms from a single fossil site in Haiti cover a rectangle measuring 1.2 by 1.8 millimeters (right), the work of German microscopist J. D. Moller in the late 19^{th} century.

A fossil of the species Stephanopyxis turris (left) resembles a topsy-turvy pillbox. When alive, the halves - one smaller than the other - connect at their open ends. This species has both asexual and sexual phases, as illustrated by the diagrams at lower left, which are based on studies by the German diatomist Gerhard Drebes. [end of Diatom Long Division portion of article]