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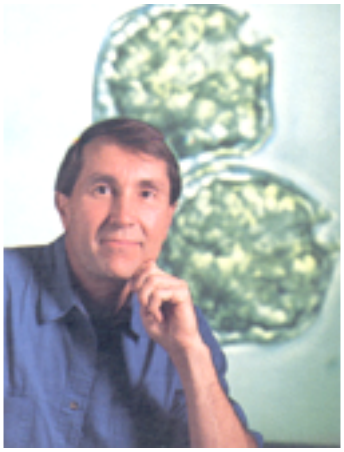
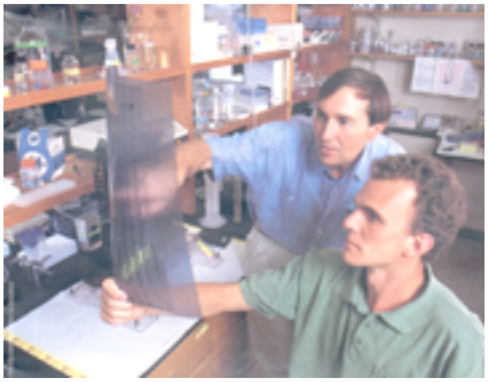
TOXIC RED TIDES ARE ON THE INCREASE, AND BIOLOGIST DON ANDERSON IS WORKING TO FIND OUT WHY.



The twisting warren of rooms in Don Anderson's lab have the beehive pace of a factory. In one nook a technician downloads data originating from a satellite high in space, while two other workers sit with their eyes glued to microscopes, tap-tapping counters, tallying thousands of cells. Down the hall, a visiting scientist from Spain experiments with antibodies, while in another room a graduate student works with DNA. The focus of their efforts are stored nearby in a bank of humming refrigerators, in jars of mud and in hundreds of test tubes holding two ounces of seawater and a floating wisp of color. These are living cultures from around the world, an archive of tiny killers that can produce poisons one thousand times more lethal than cyanide. The killers are toxic dinoflagellates, members of a class of nearly two thousand single-celled organisms found in the sea, lakes, and polar ice. The great majority of these algae are beneficial: One of the lowest links in the aquatic food chain, dinoflagellates are prey for zooplankton, and ultimately for fish, marine mammals, and human beings. But when conditions are right, dinoflagellate populations skyrocket, forming dense, colored blooms that vividly stain the water they swim in and turn it opaque as paint. Most of these "red tides" are harmless, but they can turn catastrophic—when they stop growing and decompose they rob sea life of oxygen; when alive, some produce toxins that accumulate in the tissues of animals that consume the algae as food, killing fish, birds, and marine mammals, and robbing humans, of their memories, the use of their limbs, and their lives.

Marine biologist Don Anderson and Joint Program student Gaspar Taroncher- Oldenburg examine an autoradiograph of the RNA of a dinoflagellate, a single-celled organism responsible for many toxic red tides. The differential display method they are using allows them to compare the genetics of toxic and non-toxic species, in search of the elusive genes that make the toxin.



Although one of the first recorded red tide blooms appears as a plague in the Bible ("...all the waters that were in the river were turned to blood. And the fish that was in the river died; and the river stank and the Egyptians could not drink of the water of the river." Exodus 7:Z0,21), red tide blooms still occur worldwide and at an increasing rate.

"There has been a tremendous expansion over the last twenty years and it shows no signs of abating," says Anderson, a tall, soft-spoken biologist who has focused on red tides, or harmful algal blooms (HABs), since the early 1970s.

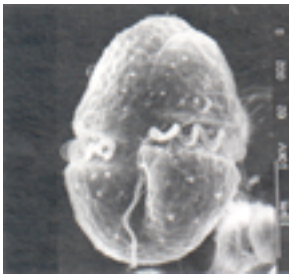
Consider this: Reports of certain types of red tide, which formerly involved only the waters of Europe, North America, and Japan, now are reported in South Africa, Australia, India, Southeast Asia, and South America. In 1985, *Allreococcus anorexeferens* turned Long Island waters into a brown soup and all but destroyed the area's multi-million dollar scallop industry. In 1987 more than one hundred people fell victim to an unprecedented outbreak of shellfish poisoning in Canada, with three dead and more than a score suffering memory loss. Scientists blame toxic *Alexarldrium tamarense* for the death of fourteen humpback whales off New England that same year; simultaneously a huge bloom of *Ptychodiscus brevis* drifted from Florida to North Carolina, closing shellfish beds and sickening scores of residents and tourists.

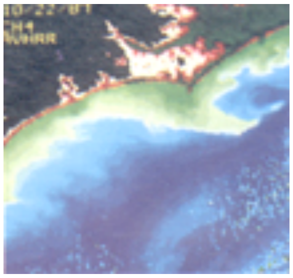
A red tide on an Italian freshwater lake. This recurring harmless bloom became a popular tourist attraction.

Anderson is spearheading an assault on the red tide epidemic, and his work has established WHOI as one of the world's leading HAB research centers. His painstaking experiments and seemingly limitless energy have made his lab in the Redfield building a Mecca to scientists and students from around the world.

"We take cruises into the coastal waters to find how the water's moving, and the way these algae are growing and getting eaten," Anderson says in his crowded office, where books and papers are piled high and e-mail arrivals regularly flash on his computer. "We grow them in the lab and look at how the nutrients we give them change the amount of toxins they produce. We're trying to find the genes that code for the toxin, and we're trying to make tests and kits to detect the toxins and the cells."

Gyrodinium uncatenum, a non-toxic dinoflagellate. The flagellum around its middle is for propulsion. The flagellum at the bottom is for steering.





In 1987, a toxic red tide developed in the Gulf of Mexico, rounded the Florida peninsula and then moved north on the Gulf Stream. Off the Carolina coast, filaments of warm water broke away from the Gulf Stream and carried the toxic cells to shore, causing a 520 million loss to tourist and shellfish industries. This remote sensing image shows the warmer water (indicated by blue) approaching North Carolina's Outer Banks.

A single red tide bloom of *Cochlodinium* killed over $7 million worth of farmed yellowtail in Japan in 1985.

"Don has shown stunning scientific leadership," says Ted Smayda, Professor of Oceanography at the University of Rhode Island. "He has put himself amongst the avant-garde in the discipline by his eagerness to acquire and test new techniques. A lot of people play it safe, but Don keeps reaching."

Part of his success, some colleagues say, comes from an uncanny ability to detect cause and effect, to see all the doors that open with each discovery. Others credit his doggedness, his unwillingness to rest until he has disarmed every potential challenge to a new solution. And more often than not, his persistence is warranted: "These cells," he says, "are always fooling us."

Despite their tiny size, dinoflagellates are enormously puzzling. Tinted with chlorophyll and other pigments, many can photosynthesize and are thus considered plants. However, they exhibit behavior normally associated with animals—they use their long, undulating tails and a waving belt about their middle to swim (dinoflagellate comes from the Greek dinos—to spin, and Latin flagellum—whip); some even eat their neighbors, and still others perform what seems to be a mating dance.

Like most single-celled algae, dinoflagellates reproduce by mitosis: Cells divide in two, the two into four, and so on. With sufficient light, nutrients, calm waters, and few zooplankton or larger animals to graze upon them, their numbers can quickly increase to millions of cells in a liter of water.

When nutrients are scarce, however, some species turn to sexual reproduction—cells split into male and female forms, which then fuse into one-celled cysts that settle on the seafloor and can survive for years. When favorable conditions return, the cysts germinate and reinoculate the water with swimming cells that can then bloom. Dinoflagellates can swim as much as ten meters per day, a key advantage when the warm sun or freshwater runoff creates a buoyant surface layer above colder, denser, nutrient-rich waters. They reside on the surface during the day, "harvesting sunlight like sunbathers," Anderson says. "They then swim down to take up nutrients by night." The result is a sudden bloom in water that seems inhospitable to growth.

Researchers are unsure why dinoflagellates produce toxins. They may incapacitate predators or cause the dinoflagellates to taste bad, or may perform an essential biochemical function and are only coincidentally harmful to other species. Scientists do know that a species' toxicity may change with differing light levels, temperature, nutrients or water agitation.

A non-toxic dinoflagellate bloom covered this Chilean beach with tremendous amounts of thick foam that eventually decayed and smelled.