FISHER SCIENCE EDUCATION

HEADLINE DISCOVERIES

MAKING SCIENCE MATTER™

ILLUMINATING THE MYSTERIES OF BIOLUMINESCENCE

In the deepest recesses of the ocean you might expect there to be complete darkness. But thanks to bioluminescence, this hidden world is host to an ever-changing light show. In this surreal landscape (between 200 and 1000 meters below the ocean surface), almost 90% of the inhabitants are bioluminescent.

Bioluminescence is the emission of visible light by a living organism. The luminous nature of creatures residing in the ocean depths has been documented for centuries by mariners who reported seeing mysterious "milky seas"—an eerie white glow that extends for miles across open water. While most prevalent among the deep sea population, bioluminescence can also be found on land, including earthworms, some bacteria and fungi, and, of course, the firefly.

Cold Light

The primary components necessary for bioluminescence are oxygen, luciferin (a molecular substrate), and luciferase (an enzyme). While the process differs slightly between species, the oxidation reaction is the same in every creature. In the presence of oxygen, enzyme and substrate act in combination to produce a short burst of visible light. And the reaction is quite efficient. A firefly converts into light almost 100% of the energy generated in bioluminescence, compared to an electric light bulb that loses over 90% of its energy to heat.

The resulting light is concentrated in the blue-green range of the spectrum, although other colors have been observed. For example, the dragonfish creates a rare red beam to locate its prey. This "night vision" is particularly effective since most sea animals cannot detect it.

Why Glow?

In the dark seas, bioluminescence is a key means of finding and attracting prey. The anglerfish uses a light organ filled with bacteria that dangles from its forehead; in the same way a fisherman might bait a brightly colored lure. The aptly named flashlight fish uses a light, produced by symbiotic bacteria living in an organ below its eye, to illuminate potential prey. Glowing fungi use their light to attract insects, not as prey, but to serve as a delivery service for their spores.

Many sea creatures use bioluminescence as camouflage or to defend against predators. Some fish can become virtually invisible by matching their glow to the color and shading of sunlight, in a process called counter-illumination. When attacked, the Atolla jellyfish generates expanding rings of blue light that can last more than half a minute. Scientists suspect this response may attract larger fish, which in turn consume the original predator. The Caribbean's Mosquito Bay contains an unusually high concentration of tiny underwater plankton called dinoflagellates, also known as "fire plants." They produce quick pinpoints of light when startled; the result of this natural burglar alarm is a spectacular display that can last all night.

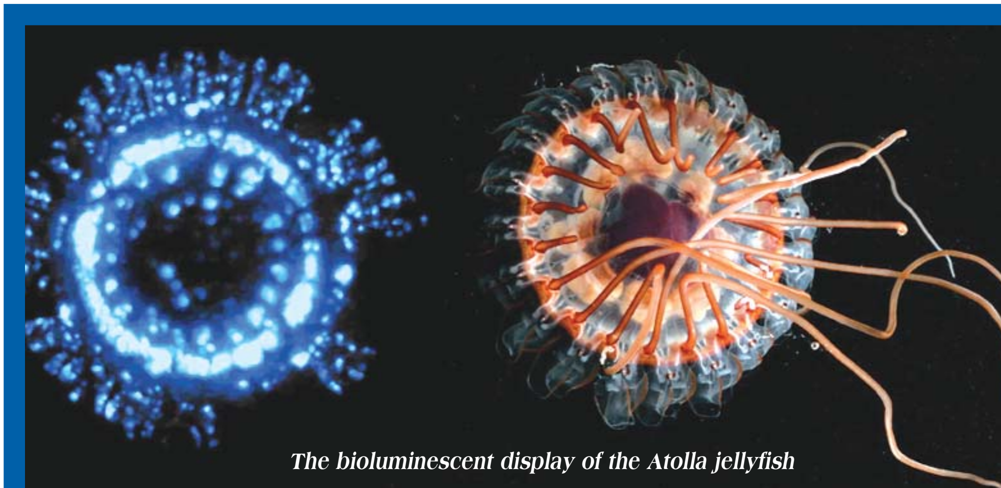
Fireflies provide perhaps the best-known example of bioluminescence, in which males and females communicate using flashes of light. There are more than 1900 known species of firefly, found in all parts of the world except Antarctica. Although not all are bioluminescent, each light-producing species uses a unique sequence of flashes to signal the opposite sex.

Light in the Lab

Dinoflagellates, one of the most common sources of bioluminescence, are also easily grown in the lab. Cultures and growth media can be readily obtained, and dinos require no more care than the average houseplant. Since their light production is on a strict day/night cycle, or circadian rhythm, studies must be performed in a darkened room during their night phase. Both mechanical (shaking) and chemical (10% acetic acid or vinegar) stimulation will produce a bioluminescent reaction that can be viewed under a microscope. Since the bioluminescence produced by a dinoflagellate indicates its overall health, scientists often use these plants to examine the harmful effects of toxins on the environment.

A Bright Future

Studies of bioluminescence have applications in many fields, including genetics, medicine, ecology, and biotechnology. Inserting a jellyfish gene into an African butterfly is helping scientists at the State University of New York (SUNY) study how genes control development. Bioluminescent ATP assays are used to identify bacterial contamination in wounds and tissues; ecologists use bioluminescent tests to assess bacterial contamination of drinking water. Life scientists use the luciferin-luciferase reaction extensively due to its extremely high sensitivity and nonhazardous nature. Some of the applications include the detection of calcium in live cells or tissues, ELISA, and high-throughput drug screening. And while researchers continue to find new species of glowing creatures in the ocean depths, others work above the surface to seek new and exciting ways to unlock the potential of bioluminescence.



The bioluminescent display of the Atolla jellyfish

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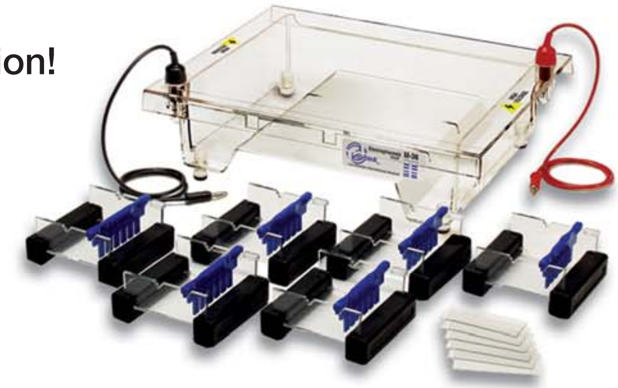

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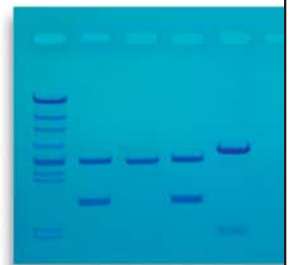

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