ANIMAL ADAPTATIONS TO LIFE IN THE DEEP SEA

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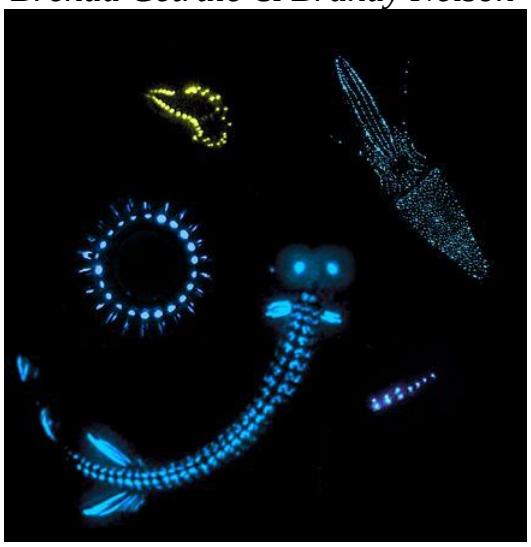

Summary

Dive down to the depths of the ocean with world-renowned oceanographer, Dr. Edie Widder, and explore the concepts of interdependence through an inquiry 5-E format. The investigation begins with a "simulated" deep-sea dive navigated by Dr. Widder. This sets the scene for a variety of lab stations that demonstrate the abiotic factors unique to the ocean's depths and they're connections to the Florida Sunshine State Standards. Dr. Widder will then connect concepts investigated in the labs stations to the ocean depths through her lecture titled "Animal Adaptations to Life in the Deep-Sea". Teachers apply what they learned and develop COSEE Florida formatted lesson plans for immediate use in the classroom.

Scientific Background

Descend two hundred meters into the ocean and the world is dark blue. Another two hundred meters and your surroundings have faded to a dim bluish-gray twilight. There is enough illumination for a person to see at that depth, but too little for photosynthesis. By the time you reach 600 m the only light visible is that directly overhead. Descend through this twilight zone another 400 meters and it becomes eternal night. The conditions in deep ocean waters include crushing pressure and frigid temperatures; and the inhabitants are some of the most amazing organisms you could ever dream exist.

The amount of sunlight in oceanic waters decreases with depth, and the color changes as the wavelengths of light become scattered and absorbed. Longer wavelengths of light, such as red, orange, and yellow, are absorbed quickly in the ocean. Shorter wavelengths, such as blue and violet, reach further into the ocean and scatter – which is why the ocean is 'blue'. The increased pressure in the deep sea is because the deeper you go in the ocean, the greater the amount of water you have pressing in upon you. These characteristics of the deep ocean, in addition to the denser cold water, combine to create an environment that was once thought to be inhospitable. Through deep-sea tools and technologies, ranging from crude net systems to advanced deep diving submersibles, and equipment like the Eye-in-the-Sea and Medusa deep-sea observatories, we can now at least gain a glimpse of deep-sea life. What we have found are animals with an array of elegant and sometimes bizarre adaptations to life in the ocean's depths.

Deep sea organisms must find food, evade predators, and find mates. One fascinating way many organisms are successful in this is through the production of light. All light in the universe is the result of the same basic phenomenon. An electron is excited to a higher energy level and as it falls back down to a lower energy state it can release its energy as a photon. The difference between different kinds of light is how the electron gets excited. When the electrons are excited by heat the light is called incandescence. Light production through other means than heating is called luminescence. Examples of luminescence include fluorescence, phosphorescence, and chemiluminescence. In fluorescence, energy from an external source of light is absorbed by a substance and immediately reemitted at a longer wavelength until the source of light is removed. Phosphorescence is similar to fluorescence, however due to the more stable state of the electrons; the reemitted light will persist after the radiant energy has been removed. Bioluminescence is a form of chemiluminescence, and refers to the ability for living organisms to produce light through a chemical reaction. Most of the animals living in the open ocean – out away from shore – are bioluminescent. There's nowhere to hide from predators in the mid-ocean and in these waters between 80 and 90% of marine organisms are bioluminescent. Bioluminescence acts as camouflage, allowing prey to hide from predators. It's also used to distract or blind predators, lure prey, and attract mates.

Two types of chemicals are required for the chemical reaction. Luciferin is the substrate which produces the light, while the catalyst is an enzyme called luciferase. There are different types of luciferins and luciferases. Most animals produce these chemicals from the food they eat. A few animals, like flashlight fish and angler fish, get their light by means of a symbiotic relationship with bioluminescent bacteria. The fish provides the bacteria with food and a good place to grow and the bacteria provide the fish with light to see by for the flashlight fish or to attract prey for the angler fish. Animals can also use their bioluminescence to attract a mate just the way fireflies do on land. Many animals use bioluminescence to avoid being eaten. For example, some can release their bioluminescent chemicals into the water to distract or temporarily blind a predator.

While most terrestrial bioluminescence is yellow and green, bioluminescence in the ocean is primarily blue. This is because evolution has favored those organisms that can communicate over greater distances.

In the open ocean there are no trees or bushes for animals to hide behind. To avoid being seen by predators some animals are transparent. Others use counterillumination to mimic the small amount of light found in the mesopelagic zone. Organisms use photophores (light organs) to match the color and inten-

sity of light coming from above. This makes these animals almost invisible to the predators below them. Animals can adjust the light from these ventral lights to match the light fluctuations from above.

Other adaptations increase the predatory and defensive success of animals in this environment. The cock-eyed squid has one eye larger than the other- the large eye looks upward, searching for silhouettes, while the small eye looks below for bioluminescence. The Loose jaw fish can unhinge its jaw and open its mouth wide to swallow things bigger than itself. The Hatchet fish has upturned eyes and mouth to search for prey above it and it has a very narrow silhouette to reduce its own shadow.

Long teeth increase the chance of catching prey, and is a common characteristic as well in the deep sea, along with dark coloration – which includes red because being red is the same as being black when there is no red light available to reflect back to your eye.

We have discovered amazing adaptations from animals we could collect and observe with slow, loud, and bright equipment. As technology advances, we will be able to observe other new animals and new adaptations of organisms that were once beyond our reach.

This lesson addresses many common misconceptions on light and interdependence. These are:

Light

- There is no light below 200 m
- Bioluminescence is the same as phosphorescence or fluorescence.
- Color is a property.
- An object is seen whenever light shines on it, with no recognition that light must move between the object and the observer's eye.
- Light is not necessary to see since we can see a little in a dark room.

Interdependence

- There is no life or very little in the deep sea.
- A species high on the food web is a predator to everything below it.
- The relative sizes of predator and prey populations are not related; and if a prey species is depleted, a predator will automatically switch to another prey species.

Grade Level and Science Courses

- Middle School 6-8
- High School Integrative Science, Biology, Chemistry, AP Biology, AP Environmental Science

Length/Duration

- Engage/Explore/Explain - 2, 90-minute blocks
- Elaborate – 2, 90-minute blocks

Objectives

During the WAH workshop:

- Scientists and teachers will collaborate on developing usable, research inspired lesson plans for Florida children.

- Scientists and teachers will share their passion for science exploration and life-long learning important to motivating and educating Florida children.
- Teachers will experience a full day of professional development that provides resources to incorporate scientifically accurate and current concepts into the curriculum, connect with other educators and the COSEE Florida network, as well as take home standards-based, hands-on materials to use in the classroom.