

Glow

Living Lights

Docent Guide

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Preface

What comes to mind when you hear the words “glow” and “living lights?” Do you remember the first time you saw flashing fireflies on a summer night? Or perhaps you witnessed mysterious lights in the ocean? Whether it was in your own backyard or discovering the unknown, it was a magical experience.

As a docent, imagine visitors touring the ***Glow: Living Lights*** exhibit for the first time. You are in a powerful position to relay visitor’s previous experiences with new connections, opening their minds and helping them to learn more about the natural world, and in turn, themselves.

This guide will assist you in interacting with visitors to the ***Glow: Living Lights*** exhibit.

About the Exhibit

Glow: Living Lights is the first traveling exhibit to explore the remarkable behavior and ecology of bioluminescence. Bioluminescence is one of nature's most incredible phenomenon. It is also one of the least understood. Relatively rare on land, it is prevalent in the mid-ocean where people don't often go. Organized and produced by Exhibit IQ, ***Glow: Living Lights*** is the only practical way to experience this fascinating occurrence.

Highlights:

- Live creatures such as dinoflagellates
- Preserved specimens, such as a cookie cutter shark
- Educational interactives
- Incredible photographs and film footage of bioluminescent animals in their environment

Exhibit Construction

Exhibit IQ strives to fabricate exhibits with Earth-friendly products such as glass, rubber, and bamboo. All our printing is on chlorine-free, post-consumer recycled paper (preferably tree free) using soy-based inks. All paints and lacquers used are non-polluting and environmentally safe.

Curatorial Expertise

James F. Case, Ph.D.

Marine Science Institute, UC Santa Barbara

James F. Case is a leader in the field of bioluminescence with interests in both marine and terrestrial forms. His extensive writings include over 140 peer-reviewed publications and three books. Currently, Dr. Case is retired as a Research Professor in the Marine Science Institute at University of California, Santa Barbara. His research interests include counter-illumination on midshipman fish, bioluminescence prediction in the coastal regime, and firefly bioluminescence communication.

Edith A. Widder, Ph.D.

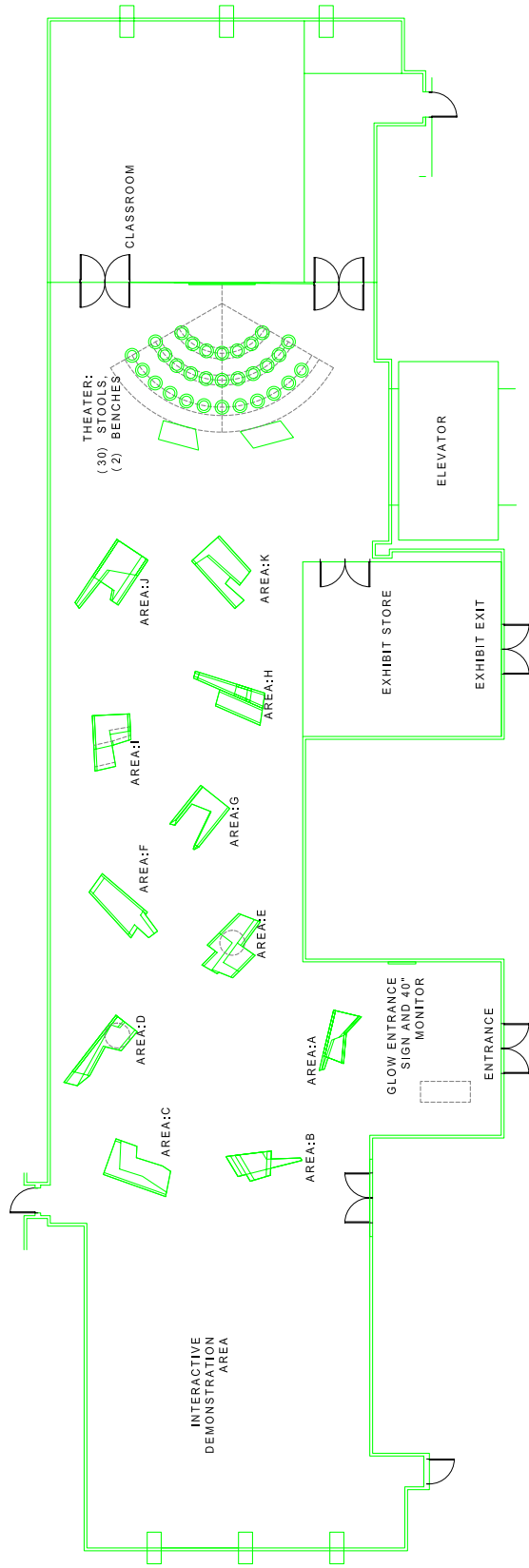
Bioluminescence Department, Harbor Branch Oceanography Institution

Edith A. Widder is a leading scientist who has conducted research on bioluminescence for over 20 years. In addition to authoring over 50 peer-reviewed scientific publications, Dr. Widder has also produced a children's book on bioluminescence, "The Bioluminescence Coloring Book" and an educational video, "Bioluminescence: Secret Lights in the Sea." Currently, Dr. Widder is Senior Scientist and Director of the Bioluminescence Department at Harbor Branch Oceanography Institution in Fort Pierce, Florida. Her research interests in bioluminescence developed out of her experience piloting the single-person submersibles, Wasp and Deep Rover.

Steve Haddock, Ph.D.

Monterey Bay Aquarium Research Institute, Monterey Bay Aquarium

Steve Haddock is a scientist specializing in bioluminescence and zooplankton. In addition to numerous peer-reviewed scientific publications and abstracts, Dr. Haddock has created a renowned bioluminescence web page. (see Resources). Currently, Dr. Haddock is a scientist at Monterey Bay Aquarium and is doing research on bioluminescence and ecology of deep sea and open-ocean ctenophores, siphonophores, and medusae. His focus is on trying to clone novel photoproteins from these group of creatures. Other research interests include blue-water diving, and submersible work on



GLOW EXHIBIT FLOOR PLAN

Scale: 3/32"=1'-0"

Exhibit Blocks

Glow: Living Lights takes visitors through a complete exploration of bioluminescence. The exhibit answers the questions of what bioluminescence is and how it differs from other forms of light. It explains the chemical reaction that produces “cool light.” Visitors go on a journey through both terrestrial and marine environments to explain why organisms “glow.” This exhibit addresses a number of scientific disciplines including biology, chemistry, oceanography, and ecology. Additionally, it dives into subject such as research methods, current and potential uses of knowledge being gained, and careers in science.

Area A: Introduction

- How Do Living Things Glow?
- The Light that Glows
- A Case of Mistaken Identity
- The Many Colors of Glow

How Do Living Things Glow?

The light that comes from living things is called **bioluminescence**. The word bioluminescence is derived from the Greek **bios** for “living” and Latin **lumine** for “light.”

Land-based creatures such as fireflies, glowworms, and certain types of snails can glow. So can some mushrooms. But most bioluminescent organisms live in the sea. An estimated **90% of marine organisms are able to glow.**

Living things use bioluminescence to do the primary things they need to survive: find food, find a mate, and avoid being eaten.

The Light that Glows

Bioluminescent organisms **produce their own light through a chemical reaction**. Two chemicals are involved: luciferin and luciferase. Luciferin is the chemical that gives off the light. Luciferase is the catalyst that brings about the reaction.

A Case of Mistaken Identity

Bioluminescence is light that comes from inside a living thing. Fluorescence and phosphorescence require an outside light source.

The rocks in the display are fluorescent. The rocks absorb light of one color and then immediately give off light of a different color.

With phosphorescence, light is emitted over a longer period of time so the glow is visible after the light source is removed. Glow-in-the-dark toys and watch faces are phosphorescent.

The Many Colors of Glow

Bioluminescence is a “cool” light, meaning very little energy is lost to heat. The chemical reaction to produce glow uses only 3% of the animal’s energy. In contrast, an incandescent light bulb is very inefficient, losing 97% of its energy to heat!

Area B: Using Light to Find a Mate

- Lighting Up a Summer Night
- How Do Fireflies Choose a Mate?
- Firefly Research
- Turn on Your Headlights

Lighting Up a Summer Night

Fireflies, or “**lightning bugs**,” are the best-known bioluminescent organisms. Did you know these glowing insects are winged beetles?

On a mid-summer evening, a dazzling light display begins at dusk. Tiny yellow lights flash every few seconds as male fireflies begin their courtship ritual. Female fireflies perched near the ground respond by flashing their own lights. Each species has its own pattern of courting.

How Do Fireflies Choose a Mate?

It’s all in the timing. When a common North American male firefly starts patrolling at dusk in search of a female, he flashes his yellow lantern once every six seconds. He becomes attracted to the female that flashes her light exactly two seconds later. This method of communication helps fireflies to find each other in order to mate.

Firefly Research

“The most lovely firefly communication system I know of is that of the **synchronously flashing fireflies** of Southeast Asia. To drift down a river after nightfall and watch the spectacular, precisely timed flashes of thousands of male fireflies – extending for a long distance – is amazing. In the lab, we discovered that each firefly flashed all by itself in the same species-specific rhythm as on the river, even when that firefly couldn’t see another firefly. Then, when they were permitted to see each other, in just a few seconds, they mutually adjusted their rhythms to get into precise group synchrony.”

– Dr. James Case, Curator, *Glow: Living Lights*.

Turn on Your Headlights

Like fireflies, Headlight beetles, famous for their bright, steady lights, **also use their glow to attract mates**. Their round light organs are located on the top of the female's head and the underside of the male.

Area C: Using Light to Find a Meal and to Pollinate

- **Glow Little Glowworm**
- **All Aboard! The Railroad Worm**
- **Even Some Earthworms Glow**
- **Tales of Glowing Mushrooms**
- **Eat at Joe's**

Glow Little Glowworm

People travel from around the world to see the display of thousands of twinkling, blue-green lights of New Zealand's Waitomo Cave. This glow is produced by Glowworms, which are not actually worms but the glowing larvae of a species of fly. As larvae, the wormlike organisms eat constantly. The glowworms make their own "fishing lines" from silk threads and sticky mucus to catch small insects. They use their **glowing taillights to attract small insects** to their fishing line. When an insect is caught, the glowworm reels in its catch by swallowing the line.

All Aboard! The Railroad Worm

South American Railroad Worms are **among the few organisms that glow in more than one color**. The females emit yellow-green light through 11 pairs of light organs along their bodies to startle predators. They use the two red headlights on their head to illuminate their surroundings.

Even Some Earthworms Glow!

Some earthworms, organisms that live underground and have no eyes, make light. Worldwide, there are more than 30 species of bioluminescent earthworms that glow in a range of colors. One species lives in New Zealand and grows up to 12 inches long. When disturbed, **it secretes a thick slime that glows bright yellow-orange**.

Tales of Glowing Mushrooms

More than 40 species of glowing fungi (mushrooms) have been identified. **They use their faint green light to attract insects**, which pick up mushroom spores and spread them to other parts of the forest. Some call the green glow **“fairy fire”** because it seems magical. A few species are called **“foxfire.”**

Eat at Joe's

There is only one known species of snail in the world that glows. Found in Southeast Asia in forests, lawns, and other moist places, they shine a yellow-green light from the underside of their upper body. It is believed that they **glow to alert other snails to a food source**. Think of it as the snail version of a neon sign in front of a café.

Area D: Using light as an alarm or cloaking device

- **Bioluminescence Rules in the Mid-Ocean**
- **Jellies with Built-in Burglar Alarms**
- **Eat Me and You'll be Sorry!**
- **The Glowing Phantom of the Deep-Sea**

Bioluminescence Rules in the Mid-Ocean

In the twilight world of the Mesopelagic zone, or mid-ocean, there are no trees or bushes to hide behind, yet **90% of the creatures are bioluminescent**. Many glowing animals avoid predators by hiding in the dark depths during the day. Others hide in surface waters by using their lights to appear transparent.

Some Jellies Have Built-in Burglar Alarms

Some jellyfish are bioluminescent, a characteristic used to ward off predators such as fish, crustaceans, and sea turtles. These jellies display light the moment they're touched, and the display produced depends on the kind of stimulus it receives. Their light displays may mean:

"Ahem! There's someone in this space." (territorial flash)

"I'm a jelly, and I'll sting you." (warning flash)

"Help! Help! I'm being attacked." (a "burglar alarm" to attract attention to a larger predator that may attack whatever is attacking the jelly!)

Eat Me and You'll be Sorry!

When this organism is touched, it not only glows, but morphs its shape from a circle to a square. Perhaps this odd **behavior serves as a warning to predators** in much the same way a skull and crossbones warns, "Don't eat me."

The Glowing Phantom of the Deep-Sea

Named for its black skin and webbed “cape,” the vampire squid **avoids predators by combining evasive maneuvers with bioluminescent displays**. When disturbed, it twists wildly, swinging its webbed arms over its head. Light-producing organs called photophores shoot out blue lights from its fins and arm tips. A glowing blue cloud appears and lasts for up to ten minutes, further confusing the squid’s predator. With an evasive turn and flip of its fins, the squid glides undetected into the darkness.

Area: E – Hiding in the Dark

- **Now You See It Now You Don't**
- **Tiny Copepods Light Up the Deep-Sea**
- **In the Deep-Sea, It's Good to be Red**
- **Siphonophores: The Longest Light Show on Earth**

Now You See It...Now You Don't

The area of the sea that is 200–650 feet below the surface is called the Mesopelagic zone, or Mid-Ocean. How do bioluminescent animals avoid predators in this dark region?

Organisms hide from predators using **counterillumination** – the use of light for camouflage. The dim blue light filtering down from the water's surface makes it easy to see the silhouettes of organisms from below. To hide, organisms such as certain jellies, squid, and fish have photophores on their bellies. These light-producing organs match the color and intensity of the light above them. The animals turn on their “belly lights” to become invisible to predators below.

Tiny Copepods Light Up the Deep-Sea

Many species of tiny crustaceans called copepods are bioluminescent. Because they are so common in the ocean, copepods are sometimes called the **“insects of the sea.”** When disturbed, copepods produce bright blue glowing clouds to distract or startle a predator.

In the Deep-Sea, It's Good to be Red

Blue is the color of most marine bioluminescence. **The color blue travels furthest through seawater**, and most sea animals make blue light and only see blue light. Red pigment absorbs blue light. For red creatures, their own skin hides their bioluminescence. In the deep-sea, red appears black because red pigment absorbs blue light. An example of this is the common comb jelly, which has a transparent body and red belly to hide the light produced by the bioluminescent prey it eats, such as krill and copepods.

Siphonophores: The Longest Light Show on Earth

The giant siphonophore is the longest bioluminescent organism. It may be the longest animal on earth, as some reach 130 feet – longer than a blue whale. Bioluminescent siphonophores use their glow as a **“burglar alarm”** to avoid predators. Their light display is reported to be the most spectacular of the deep-sea. When disturbed, they create a dazzling light show.

Area F: Using Light Tricks to Catch Your Next Meal

- **Cookie-Cutter Shark Takes Bite Out of Tuna!**
- **World's Smallest Shark is Bioluminescent!**
- **Squids**

Cookie-Cutter Shark Takes Bite Out of Tuna!

A hungry yellowfin tuna rushes toward a small fish it sees swimming above. But the fish is larger than it appears and attacks! The tuna is left with a cookie-shaped wound. The culprit is the cookie-cutter shark. **The shark's belly is covered with photophores (light-producing organs), making it invisible to predators from below** – except for a small dark collar below its jaw that looks like a small fish.

World's Smallest Shark is Bioluminescent!

Only a few deep-sea shark species are bioluminescent. This includes the world's smallest shark, the Dwarf Lantern shark, which reaches only six inches at maturity.

Most Squids in the Deep-Sea Glow

Most squids in the deep sea are bioluminescent, **allowing them to attract mates and distract predators.** Fire-shooter squids squirt out light to avoid being eaten. The Firefly squid waves around its brightly lit arms to signal alarm.

Area G: Beware of the Light!

- Plankton Light Shows
- Flashlight Fish

Glowing Plankton Sparkles & Shimmers

On a clear, moonless night, a motorboat speeds across the water's surface followed by a trail of bright blue light. What is the source of this incredible light display? Dinoflagellates. **These marine protists (very small organisms) are the most common source of bioluminescence on the ocean's surface.** Most of them are plankton – wandering protists that drift with ocean currents. Dinoflagellates use their ability to glow to protect themselves from predators. They use their glow like a burglar alarm to signal for help from other larger animals.

Flashlight Fish

Flashlight fish derive their name from the bioluminescent organs beneath their eyes. These organs are pouches of glowing bacteria. **The glow helps the fish attract prey and distract predators.** Because the bacteria glow all the time, flashlight fish have developed ways to turn off their lights. Some rotate their light organs into a special pouch. Others have a skin shutter (like an eyelid) that slides over their light organs.

Area H: Specialized Protection

- **Lighting Up the Ocean Floor**
- **Amazing, Graceful Sea Pansies and Sea Pens**
- **Love Codes in the Sea**
- **Sea Cucumber's Sticky Skin Marks Predator**

Lighting Up the Ocean Floor

Some echinoderms (sea stars, brittle stars, and sea cucumbers) are bioluminescent. **Sea stars flash their bright lights to warn predators they taste bad.** The brittle star derived its name from its habit of dropping off an arm when disturbed! The detached arm flashes brightly to distract predators while the brittle star swims away.

Amazing, Graceful Sea Pansies and Sea Pens

Sea Pansy

The sea pansy *Renilla*, related to coral and sea anemones, turns bright green when disturbed. Because *Renilla* is a colony of hundreds of feeding polyps that share a digestive, circulatory, and nervous system, its bioluminescence provides an excellent view into a simple nervous system.

Sea Pens

The graceful sea pen is a colony of polyps that share a community nervous system. This shared system coordinates the sea pen's response to predators. When disturbed, the sea pens produce beautiful waves of green light that travel up and down their plumes.

Love Codes in the Sea

Ostracods (crustaceans the size of a sesame seed) produce amazingly bright light. Often called "sea fireflies" because of the way they zip through the water, ostracods are unusual because they produce light outside their bodies. **For their courtship ritual, they secrete bright blue dots of light that are spaced apart as coded light displays.**

Sea Cucumber's Sticky Skin Marks Predator

Some bottom-dwelling sea cucumbers are graceful swimmers. Several will join together into a football-sized group and cover themselves with a thin layer of sticky, glowing skin. **If disturbed, the sticky skin lights up, peels away, and sticks to its predator making it a target.**

Bamboo Coral Lights Up the Ocean Floor

Bioluminescent bamboo coral lives on the sea floor and produces a brilliant blue glow. The coral releases an astonishing amount of slime when disturbed by bottom-dwelling fish. **The purpose of its bioluminescence seems to serve as the warning, "Don't mess with me or I'll slime you!"**

Area: I – Light Lures

- **Angling for Food and a Mate!**
- **Rare Glowing Octopus Spotted in Deep-Sea**

Angling for Food and a Mate!

The female anglerfish has a “fishing pole” atop her head, the end of which is filled with glowing bacteria. **This lure attracts prey to within snapping distance of her toothy jaws.** It also attracts males. When a male finds the right female, he attaches himself and unites their circulatory systems. He becomes an appendage that survives on the food the female consumes.

Rare Glowing Octopus Spotted in Deep-Sea

Only three known octopus species are bioluminescent. One of these has glowing suckers that flash blue light. The light attracts tiny crustaceans called copepods, its primary food source. Once the copepods move in, the octopus closes its cape and captures its meal.

Area: J – Research

- A Close Encounter of the Glowing Kind
- Exploring the Deep Sea

A Close Encounter of the Glowing Kind

Dr. Edith Widder, Founder and Senior Scientist with the Ocean Research & Conservation Association (ORCA) and co-curator of Glow: Living Lights, recalls an encounter in a one-person deep-water diving submersible referred to as a “suit.”

“One of the most thrilling bioluminescent displays happened during a dive at 500 feet, just before sunrise. Suddenly, the whole inside of the suit was illuminated with bright blue light. When I looked up, there was a siphonophore more than 30 feet long. The amount of light this creature produced must have been visible from more than 100 feet away. This encounter really brought home for me how critical bioluminescence must be for survival. It left me wanting to learn more about how and why so many animals in the ocean make light.”

Exploring the Deep Sea

Submersibles like the Johnson-Sea Link allow scientists to go thousands of feet below the surface. **The subs are outfitted with specialized equipment that make it possible for researchers to collect bioluminescent organisms**, place them into holding chambers, and bring them – alive and intact – to the surface.

Area: K – Practical Applications

- A Tool for Research
- Lights, Camera, Glow!
- Bioluminescence in Cancer Drug Research
- Practical Applications

An Important Tool for Research

Bioluminescence is a central tool in biomedical research. Its light is used to track activity inside living cells.

Green Fluorescent Protein Sheds Light for Scientists

By tagging cells with Green Fluorescent Protein (GFP) – the protein that makes jellyfish glow green – scientists can see what was once invisible. **GFP allows researchers to watch biological processes**, such as tracking nerve cells in the brain. In 2008, **the Nobel Prize in Chemistry was awarded to Osamu Shimomura, Martin Chalfie and Roger Tsien for their work in using GFP.**

Lights, Camera, Glow!

Biophotonic imaging is a technology that measures bioluminescence inside living organisms.

Using a highly sensitive camera, a dark imaging chamber to eliminate outside light, and specialized computer software to quantify the results, researchers track the progress of diseases and the effectiveness of experimental drugs.

Bioluminescence in Cancer Research

In cancer drug research, scientists tag tumor cells in lab mice with luciferase and luciferin, the two chemicals required to produce light. The mice with glowing cancer cells are then given an experimental drug treatment. **Using biophotonic imaging, scientists measure the intensity and**

location of the glowing cells. If the drug is effective, the glow decreases because fewer glowing cancer cells are present.

Lighting the Way to New Discoveries

Scientists genetically modify mice to test the effectiveness of experimental drugs for a variety of diseases. They do this by injecting the firefly luciferase gene into specific cells or organs which then allows them to measure the amount of light emitted in response to new treatments.

Practical Applications

Bioluminescence is used for many important applications. Researchers conduct aerial surveys with image-intensified cameras to locate schools of fish, reveal the location of ships, and monitor the movement of submarines and torpedoes. Food and health industries use bacterial bioluminescence to test for contaminants in soft drink bottles. Scientists use it to identify and track environmental pollutants and fireflies can even be used to help fight terrorism by helping first responders to detect the presence of harmful pathogens like Anthrax.

Discovery Cart

The Discovery Cart is a rolling cabinet (approximately 3' by 1-1/2') with a counter top that can be placed anywhere in the exhibit gallery, including your own discovery or lab space. It contains activities that docents/front line staff/volunteers can do with visitors.

Activities:

1. Use the black light to demonstrate the difference between fluorescence (rocks) and phosphoresce (glow-in-the-dark objects).
 - a. *Fluorescence (ex. fluorescent rocks) is a light emission stimulated by radiant energy, not by a chemical reaction. The emission of short rays is absorbed and then bounced off. Because of the absorbed light, electrons inside the rocks are kicked into an excited state (i.e. – they “glow”). But the electrons are unstable and they soon return to a lower level. Therefore, fluorescent rocks only “glow” when there is another light source, such as UV light, shining upon them.*
 - b. *Phosphorescence (ex.: glow-in-the-dark paint) is similar to fluorescence. The difference is that the electrons are more stable in their excited state. This makes the glowing light last for a much longer time, even after the external light is removed. Phosphorescence is the delayed emission of light that has been excited by another light source.*
2. Show how “glow” works using oversized glow sticks.
 - a. *Ask visitors how they think fireflies and other “glowing” animals make their light (results will vary). Explain to them that animals such as fireflies make a light similar to the light stick except it is created in the animal’s own bodies.*

Common Questions...with Answers!

1. **Why is bioluminescence rare on land but common in the ocean?**

On land, there are many objects such as trees and vegetation for animals to hide behind to elude predators. In the ocean, however, there are no such objects. Light also travels the furthest in the ocean because there are few obstacles.

Therefore, bioluminescence is common in the ocean because it works the best, and helps more creatures who need light on a continual basis.

2. **Why is the terrestrial bioluminescent color predominantly green while the marine color is mainly blue-green or blue?**

Bioluminescence must be seen to help an animal survive. This means the color of light must be a good match for the eyes that are meant to see it as well as the environment which the light must pass to reach those eyes. Green is the bioluminescent color most often found in terrestrial organisms. Green light best reflects off the green plants that surround animals such as the Malaysian land snail.

In the mid and deep ocean, bright blue bioluminescence works the best because it travels further than any other color. In coastal waters, where there is sand to scatter the light, blue-green travels further than blue light.

3. **Do all fireflies signal to their own species?**

Photurus, a common species of fireflies, do not play by the rules. Males and females of this species of fireflies have their own flash code pattern. However, after mating, the

female *Photurus* begins to mimic the flash codes patterns of other species to lure males to eat them.

4. Are glowworms the same as fireflies?

Firefly larvae are called glowworms. Sometimes, female fireflies are called glowworms because most are wingless and unable to fly. However, therein lies the confusion, because there are unrelated creatures with the same common name. The New Zealand glowworms are actually fly larvae. They live in caves, such as the Waitomo Cave, New Zealand where thousands of glowworms light up the dark. With their bright lights, the larvae attract the attention of flying insects which they feed upon.

5. What are the “sparkling seas?”

Although too tiny to see without a microscope, there are numerous plankton that live in the ocean. Plankton are important because many animals feed upon them, other animals feed on those animals and so forth. Some of these creatures make their own “glowing” light. Plankton might be important to eat but they don’t think so. Some “glow” as a cry for help to attract the attention of even larger animals. The larger animals might eat the animals that feed upon the plankton.

6. What is the mid-ocean and why do so many bioluminescent animals live there?

The ocean is essentially divided into three layers. The top layer, called the Epipelagic zone, has sunlight. Plankton and related creatures thrive in this layer. The bottom layer is completely enclosed in darkness. The middle layer or mid-ocean (upper 1000 meters) is where the largest numbers of bioluminescent animals are found. In the mid-ocean, there is no where to hide. An animal, swimming at depths with sunlight or moonlight above, is easily spotted as a dark shadow against the light. Many animals have evolved to create

bioluminescent belly lights or photophores to act as leopard's spots to break up their outline. This way, they are very difficult to detect.

7. All squids have ten arms. Why does the vampire squid only have eight arms?

The vampire squid (*Vampyroteuthis infernalis* or vampire from hell) is actually not a true squid but a distant cousin of squid and octopus. This creature is a present-day species from the evolutionary line that eventually split into the eight-armed octopuses and the ten-armed squid.

8. Why is there so much unknown information about some deep water animals?

Scientists know far less about deep and mid-ocean animals than those of terrestrial animals because we have only recently had the technology to create submersibles (underwater vehicles) to explore animals in these ocean depths. New submersible and other marine technology will play an important role in future discoveries about these and other amazing creatures.

Glossary

Adaptation- an adjustment to fit into different circumstances or conditions

Biology- the science of living things; study of plant and animal life

Bioluminescence- the ability of living organisms to produce a cool light through a chemical reaction in their bodies (ex. fireflies)

Blinding/distracting- some bioluminescent creatures release a cloud of blinding light into the face of an attacker, like a squid releasing a ink cloud, to try to escape

“Borrower”- some creatures do not produce their own living light. They “borrow” bioluminescent bacteria to use as a light source. However, a “borrower,” as in the case of the flashlight fish, does not return its light

Burglar Alarm – a cry for help to try to attract the attention of an even larger animal (ex. a large fish is attacking a bioluminescent squid. The light from the squid attracts the attention of a swordfish. The swordfish sees the larger fish as a meal instead of the smaller squid and attacks the fish. The squid is then able to get away.)

Camouflage- to blend into one’s surrounding to avoid being seen by others. Example: A marine creature swimming in depths where sunlight or moonlight filters down from above is easily seen as a dark shadow. Some bioluminescent creatures have photophores or belly lights. Belly lights act as leopard’s spots which break up the animal’s silhouette, making it harder to see from below.

Chemical reaction- reaction of chemical properties which convert into other substances
(In fireflies- ex. luciferin + luciferase + ATP + Oxygen = light)

Code- for fireflies, a code of flashing light is used to locate and communicate among males and females

Cool light- a chemical reaction inside a bioluminescent animal which can produce energy that is mainly light and not heat

Communication- giving or exchanging information to understand one another

Counterillumination- when a bioluminescent creature uses its photophores or belly lights to match the intensity of light from the sun or moon filtered through the depths of the ocean

Defense- the act of protecting oneself against attack or harm (see blinding/distracting & burglar alarm)

Ecology- the branch of biology that deals with the relationship of living things to their environment and each other

Food chain- an interrelated group of organisms which feed upon smaller organisms and so forth;
Example: large predators eat large fish, large fish eat smaller fish, smaller fish eat zooplankton, zooplankton eat photoplankton.

Fungi- any one group of organisms without flowers, leaves, or chlorophyll; reproduce by spores and dividing

Johnson-Sea L- submersible, from Harbor Branch Oceanographic Institution, used in research in the marine sciences; can operate to the maximum operating depth of 3,000 feet.

Lantern- the organ on some bioluminescent animals such as fireflies where light is carried or produced

Light- a form of energy created either with heat or by a chemical reaction

Light sticks- a type of chemiluminescence; a man-made product, which when bent and shaken will produce a similar light reaction to bioluminescence

“Living Light”- another term for bioluminescence; *“bio”* meaning life & *“luminescence”* meaning light

Luciferase (loo-SIF-eh-ras)- an enzyme that sets off the chemical reaction in a bioluminescent animal (see luciferin)

Luciferin (loo-SIF-eh-ruhn)- a chemical compound that reacts with oxygen to produce the bioluminescent light (see luciferase)

Lure- a device used to attract another creature (ex. A female anglerfish has a glowing lure or fishing rod on its head to attract small fish & shrimp so she can eat them. Lures can also be used to draw males of their own species)

Marine- in the ocean

Nutrients- simple chemicals which are required for plants and animals to live and grow

Oxygen- an essential gas we breathe; an ingredient needed for bioluminescence

Photophores- light organs, like little lamps on the sides of some bioluminescent creatures, where bioluminescent creatures store their light; many photophores include a lens which help direct the light produced inside, out into the water.

Plankton (*Greek term for "wanderer"*)- any tiny aquatic animal, phytoplankton and zooplankton which drift afloat in the ocean; essential as the bottom of the food chain for other creatures

Prey- any animal (animals) hunted or seized for food by another animal (see predator)

Predator- an animal that preys upon another or others (see prey)

Research- systematic study and investigation in some field of knowledge

Science- knowledge based on observed facts and tested truths arranged in an orderly fashion

Scientist- a person who has expert knowledge of some branch of science, such as biology, chemistry, physics, etc.

"Sparkling seas"- mixture of bioluminescent plankton in the ocean

Submersible- a vehicle specifically designed to operate under water

Terrestrial- on land

Warm light- light, such as a light bulb, which uses most of its energy to produce heat

Zooplankton- a type of animal plankton which gets its energy from capturing and eating

Additional Resources

“The Bioluminescence Coloring Book” by Edith Widder ISBN 0-9659686-0-X
Excellent book for all ages; accurate information; line drawings for animal reference

“Creatures that Glow” by Anita Ganeri ISBN 0-8109-4027-2
Excellent introductory book with terrestrial and marine organisms; good to read to groups; colored drawings

“The Winking, Blinking Sea: All about Bioluminescence” by Mary Batten
ISBN 0-7613-1484-9
Good simple overview of selected marine organisms; color photographs

“Nature’s Living Lights” by Alvin & Virginia Silverstein ISBN 0-316-79119-9
Excellent book with interesting facts for older students; out-of-print; blue & white animal drawings

“Fireflies” by Sylvia A. Johnson ISBN 0-8225-1485-0
Extensive overview of fireflies including life cycle; color photographs

“The Lonely Firefly” by Eric Carle
Enjoyable introductory book for younger children; colored illustrations

“The secrets of nature’s night lights” by Paul A. Zahl. National Geographic Vo. 140, No.1 July 1971 p. 45
Older yet still relevant information for older children; excellent color photographs

“Light in the Ocean’s Midwater” by Bruce H. Robinson Scientific American Vol. 273 July 1995. pg. 60
Excellent bioluminescent information for older children 21

“The Light Connection: Symbiotic Relationships Illuminate Underwater World” by Joe Hlebica Explorations, Scripps Institution of Oceanography Vol. 4 No.2 Fall 1997 p. 2
Excellent bioluminescent information for older children

On-line Resources

Explore these links to learn more about bioluminescence.

<http://www.nationalgeographic.com/xpeditions/lessons/08/g68/seasbiolum.html>

<http://oceanexplorer.noaa.gov/explorations/09bioluminescence/background/edu/lessonplans.html>

<http://nationalzoo.si.edu/animals/invertebrates/facts/cnidarians/bioluminescence.cfm>