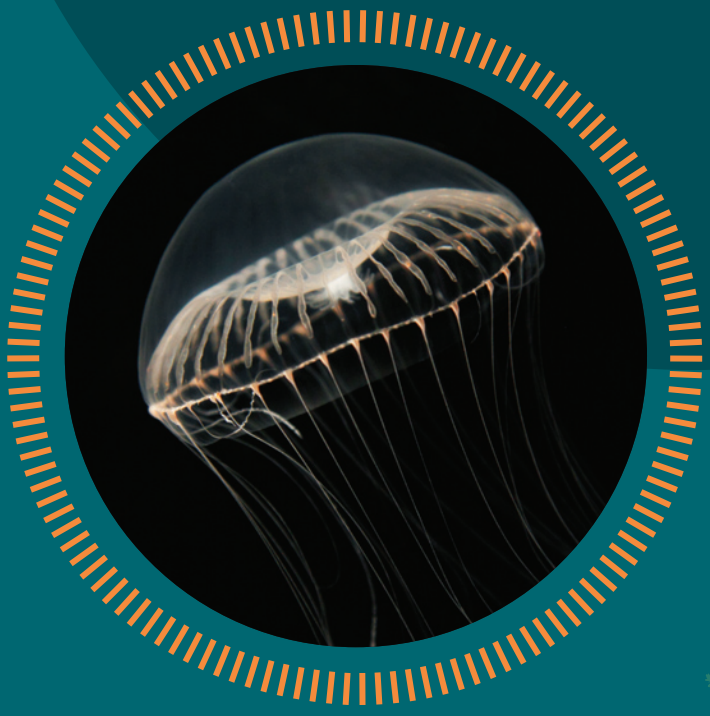
American Museum of Natural History

Educator's Guide

CREATURES OF LIGHT

NATURE'S BIOLUMINESCENCE



Inside:

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- ESSENTIAL QUESTIONS for Student Inquiry
- Strategies for TEACHING IN THE EXHIBITION
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- ONLINE RESOURCES for the Classroom
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- GLOSSARY

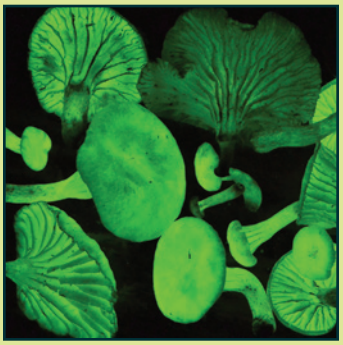
amnh.org/education/creaturesoflight

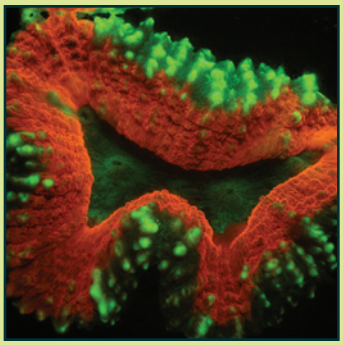
ESSENTIAL Questions

Travel from a warm summer meadow to the deep sea to explore the phenomenon of bioluminescence: living things that "glow," or emit light. What kinds of organisms are bioluminescent? Where are they found? What are some possible functions of the ability to glow? **Use the Essential Questions below to connect the exhibition's themes to your curriculum.**

What is bioluminescence?

Bioluminescence is a chemical reaction that takes place in an organism and produces detectable **light**. These organisms use a variety of body parts to emit light in different colors and for different purposes. This chemical process is different from **fluorescence**, another process that can cause things to emit light. In a few organisms, bioluminescence and fluorescence both occur.





Left: These bioluminescent mushrooms grow on decaying wood in North American forests. Right: These corals are fluorescent: they glow when blue or violet light shines on them.

How does bioluminescence work?

This **chemical reaction** requires at least three ingredients. An enzyme known as luciferase acts upon an organic molecule called luciferin in the presence of oxygen. The reaction produces a molecule called oxyluciferin, and energy. The energy takes the form of photons, units of light.

Some bioluminescent organisms produce their own light, either making all of the ingredients themselves or making everything but luciferin, which they take in through their diet. Other bioluminescent organisms, such as the flashlight fish, do not produce their own light. Instead, they have a **symbiotic** relationship with bioluminescent bacteria that live inside their bodies.

What organisms are bioluminescent?

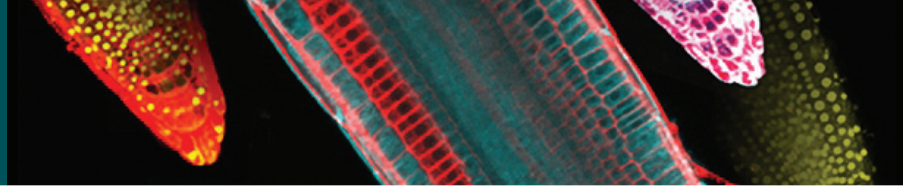
An astounding variety of creatures make their own light, and bioluminescence has evolved independently in organisms as different as mushrooms and sharks. In fact, this trait has evolved at least fifty times on the **Tree of Life**! Bioluminescent organisms range from marine bacteria and other **plankton**, to corals, sea slugs, crustaceans, octopuses, and fishes. There are also bioluminescent fungi, worms, and insects, but no bioluminescent flowering plants, birds, reptiles, amphibians, or mammals.

Where are bioluminescent organisms found?

Eighty percent of all bioluminescent groups live in the world's oceans, from the shallows to the deep sea floor. Some organisms that live near the surface, like flashlight fish and single-celled **dinoflagellates**, have evolved to use their bioluminescence at night. In the deep sea nearly all the organisms glow, an **adaptation** for living in perpetual dark. Less frequently, bioluminescence also occurs on land, ranging from fireflies flashing in the grass to mushrooms in dark woods and glowworms shimmering in caves.

How do organisms use bioluminescence to survive in their environment?

Scientists have observed organisms using bioluminescence in many different ways. These include self-defense, illuminating or luring prey, camouflage, and attracting mates. For example, the vampire squid squirts out a cloud of bioluminescent fluid that may confuse predators. Glowing spots on the "shoulders" of the click beetle give the impression of a much larger animal crawling at night. Some species of fireflies communicate with flash patterns to signal their availability and attract potential mates. Dinoflagellates light up when disturbed, perhaps to startle predators — or to attract animals that may eat their attackers. Rows of light organs on the undersides of the hatchet fish help it blend with light from above, making it barely visible to a predator looking up from below. The **larvae** of fungus gnats glow to attract insects to their sticky "fishing lines," while biologists think that the deep-sea stoplight loosejaw fish uses its red light (a color invisible to most deep-sea organisms) to illuminate its prey. While we know a lot about how bioluminescence works and how organisms use it, we have a lot more to learn. Many intriguing bioluminescent organisms await discovery as we explore Earth's final frontier, the **deep sea**.



GLOSSARY

adaptation: a physical or behavioral characteristic that allows organisms to better survive in a particular environment

bioluminescence: a chemical reaction in organisms that produces detectable light

chemical reaction: a process that occurs when two or more molecules interact, creating a substance that wasn't there before

deep sea: the ocean depths, typically below 1,000 meters (3,280 feet), where little or no light penetrates. Largely unexplored, the deep sea actually contains most of the habitable space on Earth.

dinoflagellate: single-celled animals, many of which photosynthesize

fluorescence: a process in which light of shorter wavelength is absorbed and re-emitted as longer-wavelength light that changes color, such as from blue to red. Many organisms fluoresce, including corals, sea anemones, and fish.

larva: the newly hatched, often wormlike form of many organisms before they metamorphose into adults

light: electromagnetic radiation. Visible light makes up a small fraction of the electromagnetic spectrum.

phosphorescence: a process in which light absorbed from one source is re-emitted very slowly, so that the glow persists even after the original source has gone dark. Naturally occurring minerals and manmade objects like glow-in-the-dark stickers phosphoresce, but no living things do.

plankton: tiny organisms (plants, animals, archaea, and bacteria) that drift in water

symbiosis: prolonged interaction between two different organisms that typically benefits both species

Tree of Life: a branching diagram that shows how all forms of life, both living and extinct, are related

COME PREPARED

Plan your visit. For information about reservations, transportation, and lunchrooms, visit amnh.org/education/plan.

Read the Essential Questions in this guide to see how themes in *Creatures of Light* connect to your curriculum. Identify the key points that you'd like your students to learn from the exhibition.

Review the Teaching in the Exhibition section of this guide for an advance look at the models, specimens, and interactives that you and your class will be encountering.

Download activities and student worksheets at amnh.org/resources/rfl/pdf/creaturesoflight_activities.pdf. Designed for use before, during, and after your visit, these activities focus on themes that correlate to the New York State Science Core Curriculum.

Decide how your students will explore the *Creatures of Light* exhibition. Suggestions include:

- You and your chaperones can facilitate the visit using the **Teaching in the Exhibition** section of this guide.
- Your students can use the **student worksheets** to explore the exhibition on their own or in small groups.
- Students, individually or in groups, can use copies of the **map** to choose their own paths.

CORRELATIONS TO NATIONAL STANDARDS

Your visit to the *Creatures of Light* exhibition can be correlated to the national standards below. Visit amnh.org/resources/rfl/pdf/creaturesoflight_standards.pdf for a full listing of New York State standards.

SCIENCE EDUCATION STANDARDS

All Grades • A2: Understanding about scientific inquiry • E2: Understanding about science and technology • G1: Science as a human endeavor

K–4 • B3: Light, heat, electricity, and magnetism • C1: The Characteristics of Organisms • C3: Organisms and environments

5–8 • B3: Transfer of energy • C1: Structure and function in living systems • C3: Regulation and behavior • C5: diversity and adaptations of organisms • G2: Nature of science

9–12 • B3: Chemical reactions • B6: Interactions of energy and matter • C1: The cell • C4: Interdependence of organisms • C6: Behavior of organisms

Teaching in the EXHIBITION

This exhibition uses immersive environments, models, specimens, videos, and hands-on and computer interactives to investigate the phenomenon of bioluminescence. It moves from terrestrial environments into the marine environments where most bioluminescent organisms are found.

The Guided Explorations below are designed around the theme of observation. Students will explore what these organisms have in common — they all "glow," or emit light — and also observe that different phenomena are at work. Most are bioluminescent (make their own light), but some are fluorescent (absorb and re-emit light) and a few are both.

PREPARE FOR DARKNESS

The exhibition space will be dim, the Sparkling Sea and Deep Ocean sections in particular. Although there will be ambient light, we recommend reading this guide in advance so that you can guide students in the exhibition.

LAND

Bioluminescence is rare on land, which makes it seem even more surprising when we do come across it. Scientists are just beginning to delve into the mystery of why these unusual terrestrial organisms glow.

1. Woods: Mushrooms

OVERVIEW: In the forests of eastern North America, bioluminescent mushrooms grow on decaying wood.

GUIDED EXPLORATION:

- **Models of Mushroom Species:** Point out to students that very few land organisms glow. Ask students to note what part of each mushroom is glowing, and what color light it emits.

2. A Summer's Night: Fireflies

OVERVIEW: In a grassy clearing in eastern North America, fireflies are using a system of flashes to communicate: to attract mates and also to lure other firefly species close enough to catch and eat. The light may also discourage predators by signaling that the firefly will taste bad.

GUIDED EXPLORATIONS:

- **Wall Mural of Grassy Field:** Draw students' attention to the mural, and invite them to imagine a summer evening and describe this environment. (Descriptions may include: this is grassy countryside; it's lush and well-watered)
- **Larger-Than-Life Firefly Models:** Have students identify and observe the body part that's glowing, and to describe the color being generated. (Answer: The light comes from a tiny organ called a lantern, on the underside of the abdomen.) Ask: How do fireflies use bioluminescence? (Answer: to attract and find mates; to lure and prey on other species of firefly.)
- **"Talking to Fireflies" Hands-on Interactive:** Invite students to try to communicate with flash patterns. Ask if they know of a similar signaling system used by humans. (Answer: Morse code)

3. A Mysterious Cave: Glowworms

OVERVIEW: On the ceiling of New Zealand's Waitomo Cave, glowworms secrete threads studded with adhesive droplets that reflect light from their bioluminescent tails. These tails glow brighter when the animals are hungry. When aquatic insects from the stream below fly toward the light, they become tangled in these lines. The glowworms then reel in their catch.

GUIDED EXPLORATIONS:

- **Glowworm Cave Model:** Have students take turns peering into the cave and describing both the light and the place where it occurs. (Descriptions may include: the ceiling of the cave is speckled with greenish-blue lights; the cave is dark and rocky; the bottom is wet.). Tell students that glowworms aren't worms at all (they're the larvae of small flies), and that one larva can produce more than forty adhesive lures. Ask students where they think the larvae live. (Answer: Students can trace threads to the ceiling of the cave, where the larvae live.) What is the function of the glowworms' bioluminescence? (Answers: The light reflected in the threads lures prey towards these sticky traps.)

The larva's "fishing lines" are mucus threads studded with adhesive droplets.

- **Display of Terrestrial Species:** Invite students to observe the millipede model and the click beetle specimen. Ask: What parts of their bodies glow? What color light do they emit? What purposes might their bioluminescence serve in these very different animals? (Answers may include: The whole millipede glows. The light is greenish-blue. It intensifies when they're disturbed, perhaps signaling that they're poisonous. The glowing green spots on the shoulders of the click beetle look like eyes, making it look like a bigger animal.)

Bioluminescence is much more common in water than on land. By far **the greatest diversity of bioluminescent organisms live in the deep sea**, where upwards of 80% of organisms exhibit the phenomenon.

4. A Sparkling Sea: Dinoflagellates

OVERVIEW: It's nighttime at a quiet lagoon in Vieques, Puerto Rico. The bay is full of marine organisms known as dinoflagellates, each the size of a pinprick. When something bumps into a dinoflagellate, the impact triggers a chemical reaction that ends in a burst of light. No one really knows why dinoflagellates flash on contact, but scientists think it may startle or expose predators, or help remove toxic oxygen from their bodies.

GUIDED EXPLORATIONS:

- **Interactive Lagoon:** Stop on the boardwalk and have students look around and describe the environment. (Descriptions may include: We're in a mangrove forest; it's nighttime.) Invite them to imagine that they're about to swim in a Caribbean lagoon. Have them describe the experience of walking on the interactive floor. (Answers may include: blue lights appear wherever my feet touch the floor) Explain that the glowing mimics the light caused by touching millions of dinoflagellates, microscopic organisms that live in this sheltered, shallow bay.

- **Live Dinoflagellates Tank & Model:** Have students look closely at these live plankton and examine the 11,000-times-life-size model of one species. Ask: What purpose do you think its bioluminescence serves? (Answers may include: The chemical reaction might act as an antioxidant, removing oxygen radicals from the organism, and releasing light as a byproduct; the light may startle attacking predators; the light may reveal other, larger species around the dinoflagellate to predators.)

5. Sea Shores: Corals, Jellies, & Fishes

OVERVIEW: Fluorescence can also cause organisms to glow by transforming and reemitting light from an external source. In the Caribbean Sea, shining a blue or violet light onto corals makes them glow in neon shades of pink, orange, and green. In the Pacific Ocean, spots on the rim of a jellyfish light up when touched. Its mysterious green glow is the product of both bioluminescence and fluorescence.

GUIDED EXPLORATIONS:

Remind students that all the organisms they've observed so far are bioluminescent — they create their own light. Tell them that this section displays some that are fluorescent, not bioluminescent: they absorb one color of light and emit another.

- **Coral Reef Wall, Jellyfish Models, Ponyfish Model, & Live Flashlight Fish:** Have students explore these three sections to discover and learn about the animals featured here. Then ask: What makes the corals, jellyfishes, and ponyfishes glow? How are these processes similar and how do they differ? (Answers may include: Corals are fluorescent; they absorb and re-emit light shined by divers in longer-wavelength colors. The jellyfish is both fluorescent and bioluminescent; luciferin and luciferase make blue light inside miniature light organs, and a fluorescent molecule turns the blue light to green. The ponyfish is bioluminescent; a ring of tissue around its throat is packed with bioluminescent bacteria.) Ask: What are some of the possible ways in which light may benefit these organisms in their environments? (Answers may include: In corals, fluorescent molecules may serve as a sunscreen, help injured corals heal, and capture damaging oxygen; light may also attract prey. On other animals, fluorescent markings may serve as mating signals. Ponyfishes use their bioluminescent light for camouflage and to attract mates.)

- **Fluorescent & Phosphorescent Objects:** Explain that fluorescence occurs when an object absorbs and then re-emits light, and that phosphorescence is a type of fluorescence in which the light is re-emitted very slowly, even after the original light source has gone out. Have students observe these minerals and household items.

6. The Deep Ocean: Predators & Prey

OVERVIEW: In the perpetually dark deep ocean, the only glimmers of light come from living things. Here, the vast majority of animals light up as they travel, hunt, and mate.

GUIDED EXPLORATION:

- **Theater & Models:** Tell students that they're now going to explore a completely dark environment. Point out that the animals they'll observe will have very different adaptations and behaviors than any they've seen so far. First, have students watch the movie about the deep-sea environment and its inhabitants. Then have students examine the models of deep-sea organisms and describe the ways in which different organisms use bioluminescence. (Answers may include: The female anglerfish uses a glowing lure to attract prey. The tubeshoulder, a type of fish, blasts a stream of lighted fluid that could stun an attacker while it escapes. The siphonophore, a relative of jellyfishes, uses red lures to entice fish towards its tentacles. The hatchetfish adjusts the light on the underside of its body to blend in with the faint light from above and hide from predators lurking below.)

ONLINE Resources

OLogy: The Museum's Website for Kids
amnh.org/ology/
Search for the term "bioluminescence" in the purple sidebar to find a bioluminescent creatures paper cutout activity and "They Glow!", a sing-along about ocean animals that glow.

Jellies Down Deep
sciencebulletins.amnh.org/?sid=b.f.jellies.20040615
In this seven-minute video, marine biologists study jellies in the deep-sea water column.

Photos of Luminous Organisms
lifesci.ucsb.edu/~biolum/organism/photo.html
An extensively annotated photo gallery of marine organisms and related phenomena.

Glow: Living Lights
sdnhm.org/archive/exhibits/glow/
The San Diego Natural History Museum's 2003 exhibition about bioluminescence. Includes Teacher's Guide.

Glowing Sea Beasts
on.natgeo.com/i7mToA
Selected photos by a National Geographic photographer.

Lanternfish Sticks
montereybayaquarium.org/lc/activities/lanternfish_sticks.asp
A make-your-own glow-in-the-dark fish activity.

Growing Dinoflagellates At Home
lifesci.ucsb.edu/~biolum/organism/dinohome.html
Experiment with them to understand more about bioluminescence.

National Geographic Education: Bioluminescence
beta.education.nationalgeographic.com/education/encyclopedia/bioluminescence
The National Geographic encyclopedia entry, with a focus on defensive adaptation.

New Glowing Fungi Species Found in Brazil
news.nationalgeographic.com/news/2006/10/photogalleries/glowing-fungi/
An article about bioluminescent mushrooms found in Brazil, with image gallery.

FACTS OF LIGHT

- **Bioluminescence** is "cold light" that gives off almost no heat.
- **In water, blue and green light** travel much farther than other wavelengths. Most marine animals are adapted to see only these colors of light.
- **Most of the ocean is dark.** Here in the deep sea, beyond the reach of sunlight, most animals — upwards of 80% — light up as they travel, hunt, and mate.
- **Fireflies aren't flies at all.** They're beetles! Sometimes they're called lightning bugs.

CREDITS

Creatures of Light: Nature's Bioluminescence is organized by the American Museum of Natural History, New York (www.amnh.org) in collaboration with the Canadian Museum of Nature, Ottawa, Canada and The Field Museum, Chicago.

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MAP of the Exhibition

CREATURES OF LIGHT

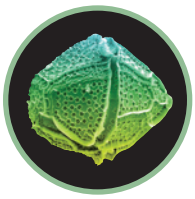
Travel from a warm summer meadow to the deep sea floor to explore the phenomenon of bioluminescence: living things that "glow," or emit light.

1. Woods: Mushrooms

2. A Summer's Night: Fireflies

3. A Mysterious Cave: Glowworms

4. A Sparkling Sea: Dinoflagellates

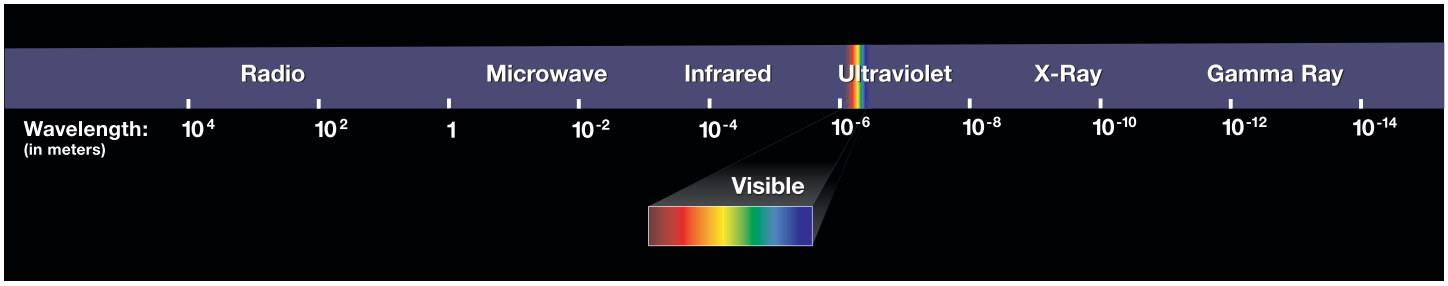


5. Sea Shores: Corals, Jellies, & Fishes

6. The Deep Ocean: Predators & Prey

Understanding LIGHT

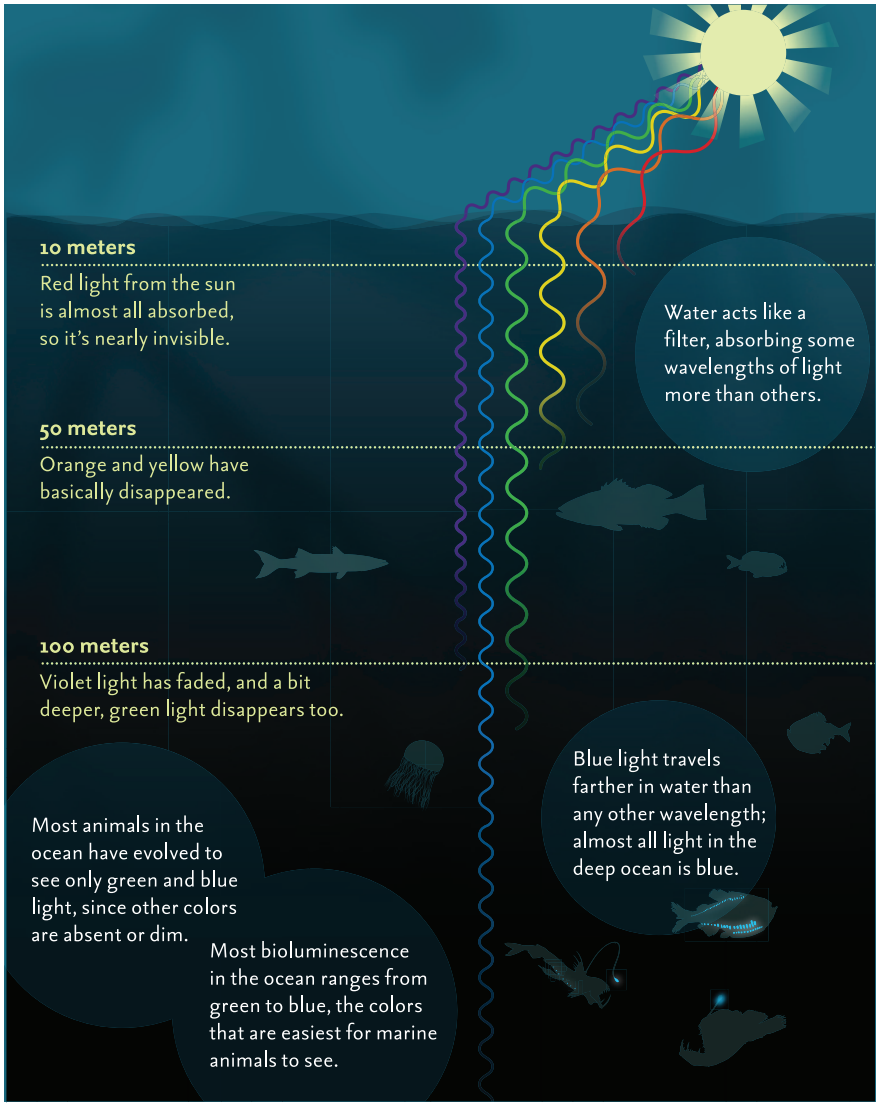
The Electromagnetic Spectrum



Light is a kind of energy (electromagnetic radiation) that travels in waves. These waves range from very long-wavelength, low-energy radio waves to very short-wavelength, high-energy gamma rays. Only a fraction of these wavelengths, which we see as different colors, are visible to human eyes.

Light Beneath the Waves

On land, sunlight illuminates a world that's bright and bursting with color. But in the **ocean**, light and color diminish as the water gets deeper. Take a look at what happens to light as it moves through the water, and how marine organisms have adapted.



Observe Creatures That Glow

OVERVIEW

In these activities, students will hone their observation skills while learning about bioluminescent animals.

- **Before Your Visit:** Students will practice observing animals and identifying body parts, then be introduced to some animals that glow.
- **During Your Visit:** Students will focus on specific animals and how the light they emit helps them survive.
- **Back in the Classroom:** Students will share their findings and demonstrate how bioluminescence can help an animal communicate.

NYS Science Core Curriculum

LE 3.1a: Each animal has different structures that serve different functions in growth, survival, and reproduction.

BACKGROUND FOR EDUCATOR

Bioluminescence is a chemical reaction that takes place in an organism and produces detectable light. These organisms use a variety of body parts to emit light in different colors and for different purposes. Eighty percent of all bioluminescent groups live in the world's oceans, from the shallows to the deep sea floor; they include fish, plankton, crustaceans, and jellyfish. Although less common, bioluminescence also occurs on land in some insects and fungi. Scientists have observed organisms using bioluminescence in many different ways. These include self-defense, illuminating or luring prey, camouflage, and attracting mates.

BEFORE YOUR VISIT

1. Activity: Observe Animal Body Parts

Materials: pictures or models of animals, including (but not necessarily limited to) insects, fish, and jellyfish.

Pair students up, and give each pair one animal picture or model. Students may start by naming parts of their own bodies (e.g. arms, legs, head, eyes). Next, have them closely observe the photo/model. Ask students to identify the animals' various body parts and explain their purposes. Ask: How do these body parts help this animal live/survive? What's the corresponding part of your body? How are the two similar or different? (Answers will vary.) Have students discuss their observations with each other, and if time allows, share their observations with the class.

2. Activity: Bioluminescent Animals

Materials: Computer and projector

Ask students if they can think of any animal in nature that produces light with its body. (Answers may include: fireflies, fish). Tell them that there are actually many kinds of animals with body parts that light up, and that this ability is called "bioluminescence." Tell students that the video they're going to watch was filmed in the deep ocean where it's totally dark. Some of the animals in the video are bioluminescent (produce their own light).

Plan how your students will explore *Creatures of Light* using the Animal Investigation Worksheets (see pre-visit activity #3). Since the exhibition will be dark, we recommend that students take mental notes in the exhibition and record their observations afterwards.

Before your visit, divide your class into six teams: Firefly, Jellyfish, Deep-Sea Anglerfish, Stoplight Loosejaw Dragonfish, Vampire Squid, and Bristlemouth.

At the Museum, each group should be facilitated by a teacher/chaperone as they explore the exhibition. Distribute copies of the corresponding **instructions** and **worksheets** to chaperones and students beforehand, and review them together to make sure everyone understands the activities. To each chaperone, also distribute the instructions and one **crayon** of each of the following colors: red, blue, purple, green, and yellow.

Show students this video:
montereybayaquarium.org/videos/Video.aspx?enc=oZZ+8rD1FkYIbAdCXUUyqw

After watching the video (multiple times if necessary), ask: What kinds of animals could you identify? (Answers may include: squid, jellyfish, fish, shrimp,) Were any animals totally unfamiliar? (Answers will vary.) Did you notice any of lighting up? (Answers may include: jellyfish) What parts of their bodies did the light come from, and what colors did you see? (Answers may include: the fish had lights on its underside, the red animal had rows of flashing lights on its sides, the fast animal had lights on the ends of ots feet/tentacles. The lights were green, white, red, purple.)

3. Activity: Prepare for the Exhibition (Animal Investigation Team Formation)

Uses worksheets with diagrams of individual bioluminescent animals to prepare students to explore the *Creatures of Light* exhibition. Use your discretion when assigning diagrams and deciding what size groups to create. For a more intensive experience, groups may be given multiple animals to investigate.

Materials: copies of animal worksheets: Firefly, Jellyfish, Deep-Sea Anglerfish, Stoplight Loosejaw Dragonfish, Vampire Squid, Bristlemouth

Tell students that these are a few of the bioluminescent animals they'll be observing in the exhibition. Split them into as many as 6 groups: (1) Firefly, (2) Jellyfish, (3) Deep-Sea Anglerfish, (4) Stoplight Loosejaw Dragonfish, (5) Vampire Squid, and (6) Bristlemouth. Tell them that each group is an Animal Investigation Team, which will learn as much as possible about its animal. Distribute the worksheets. (All members of each team should receive a diagram of the same animal.) Have the teams look carefully at the animal, then discuss it together: What kind of animal is it? What body parts of it can they identify? (Answers may include: wings, tentacles) Where do they think it might live? (Answers may include: in a forest, in the ocean) Tell the class that these animals are all bioluminescent. Explain that in the exhibition they will find and study a large model of that animal, identify which part of it lights up, and learn about how the animal might use this light to survive.

DURING YOUR VISIT

Creatures of Light: Nature's Bioluminescence

4th floor (45 minutes)

Divide your class into the same six groups: (1) Firefly, (2) Jellyfish, (3) Deep-Sea Anglerfish, (4) Stoplight Loosejaw Dragonfish, (5) Vampire Squid, and (6) Bristlemouth. Have an adult chaperone guide the students through the exhibition and facilitate the activity.

Materials:

- For each student: an animal diagram sheet (based on his/her team)
- For each chaperone: instructions, an animal diagram sheet, and five crayons (red, blue, purple, green, and yellow)

Milstein Hall of Ocean Life

1st floor (30 minutes)

In the open space beneath the whale, have students regroup, review, and take notes on the things they saw in the *Creatures of Light* exhibition.

Materials: Same as *Creatures of Light* materials, plus one pencil for each student.

Have students gather in front of the Deep Sea Ecosystem on the right hand side of the upper level*. With this environment as a backdrop, have them continue working on their *Creatures of Light* worksheet by labeling any parts of their animal they can identify, and answering the four questions. Alternatively, for younger students, you and/or the chaperones can use the questions to lead a group discussion and record students' responses on a single sheet.

Afterwards, have students practice their observation skills by spotting animals in the Deep Sea display and discussing which body parts they can identify and what their functions might be.

***Note:** If you have a very large group, you may choose to conduct this activity in front of one of the Lower Level dioramas under the whale, where there is more space; e.g. the Dolphin and Tuna diorama on the left-hand side.

BACK IN THE CLASSROOM

Students will share their findings, and demonstrate how bioluminescence can help an animal communicate.

Activity: Sharing Observations & Recording Findings

Materials: One clean copy of each worksheet (enlarged, if possible); blue, green, purple, red, and yellow crayons; black markers for labeling

Have student groups present what they learned in *Creatures of Light* to the rest of the class. Post clean copies of all of the animal outlines in front of the class. Have representatives from each group come up one at a time and fill in the details by coloring in the bioluminescent parts in the appropriate color and labeling the body parts. They can refer to their worksheets. With younger students, you may want to read findings aloud and label the diagrams, and then have students add color. When identifying bioluminescent parts of the animal's body, ask students how bioluminescence helps it live/survive. Include this information on the diagram.

Activity: "Lanternfish Sticks"

Students will create a simple model of a bioluminescent fish, then learn how it uses bioluminescence to communicate.

Go to montereybayaquarium.org/lc/activities/lanternfish_sticks.asp for full instructions and materials. Be sure to follow the link at the bottom for instructions on conducting the activity with the fish.

Instructions for Chaperones

Check your assigned Animal Investigation Team:

☐ Firefly ☐ Jellyfish ☐ Deep-Sea Anglerfish

☐ Stoplight Loosejaw Dragonfish ☐ Vampire Squid ☐ Bristlemouth

1. **Before entering the exhibition**, tell students that they will need to pay attention to each animal model they encounter so that each group can find and recognize its animal.

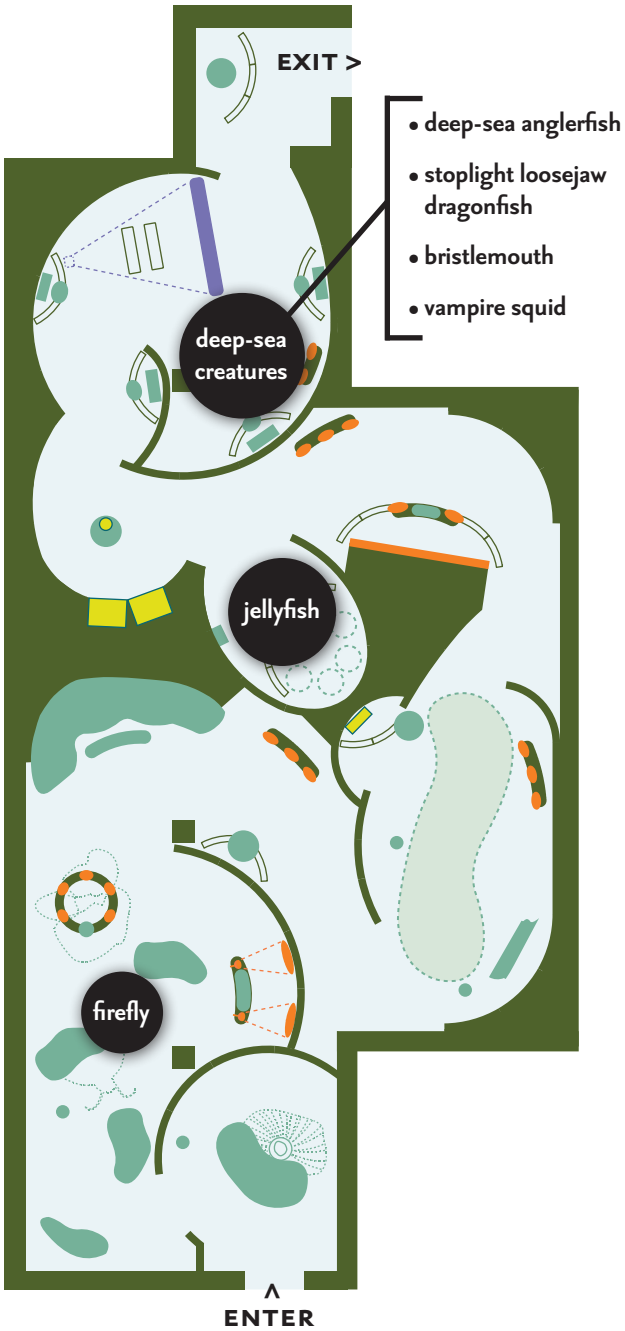
2. **When a group of students has found its animal**, gather around the model.

3. **Ask students to identify** which part of the animal is glowing and what color that part is.

4. **Pass around the corresponding color crayon** and have students take turns coloring in that body part on their sheet. (If it's too dark, do this step after the exhibition.)

5. **While students are coloring,** prompt students to make observations about the animal. (They do *not* need to write these answers down while in the exhibition.)

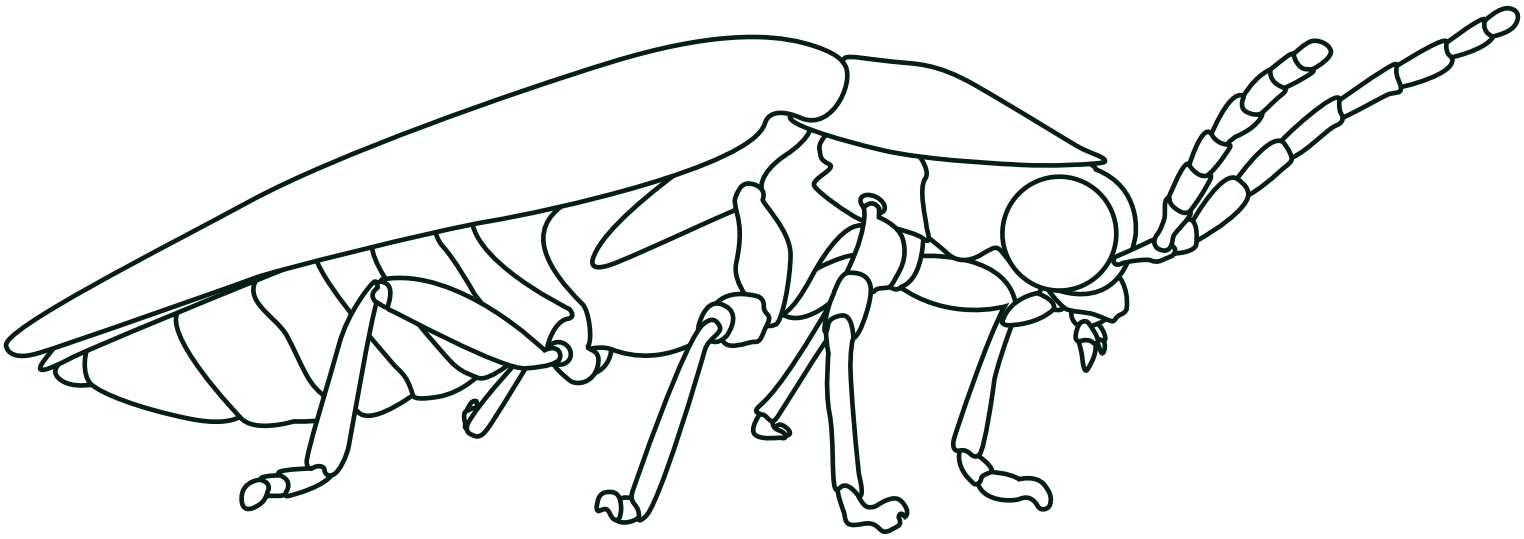
   - How many body parts (glowing or not) can you identify?
   - What does the animal use these parts for?
   - What purpose might the bioluminescence serve?
   - Are there any clues around the animal or on the panels nearby?



Student Worksheet

TEAM: Firefly

Name: _____

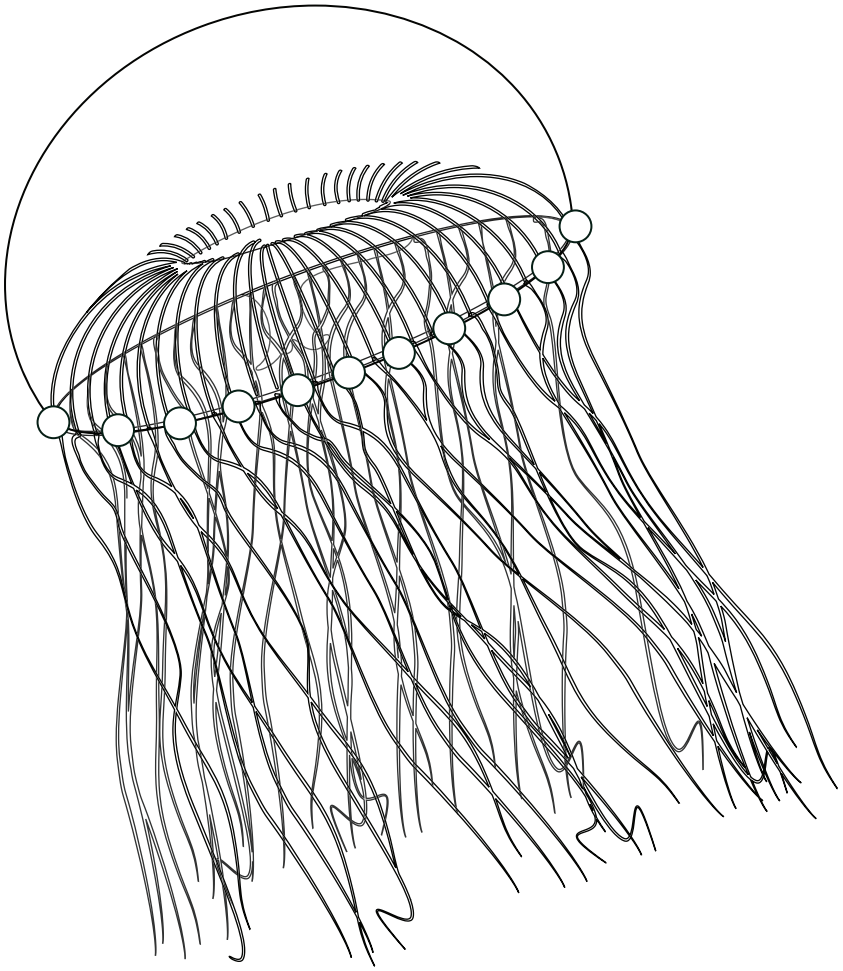


Describe the environment that your animal lives in.	How does your animal use this light?
What parts of your animal are glowing?	What color is the light?

Student Worksheet

TEAM: Jellyfish

Name: _____

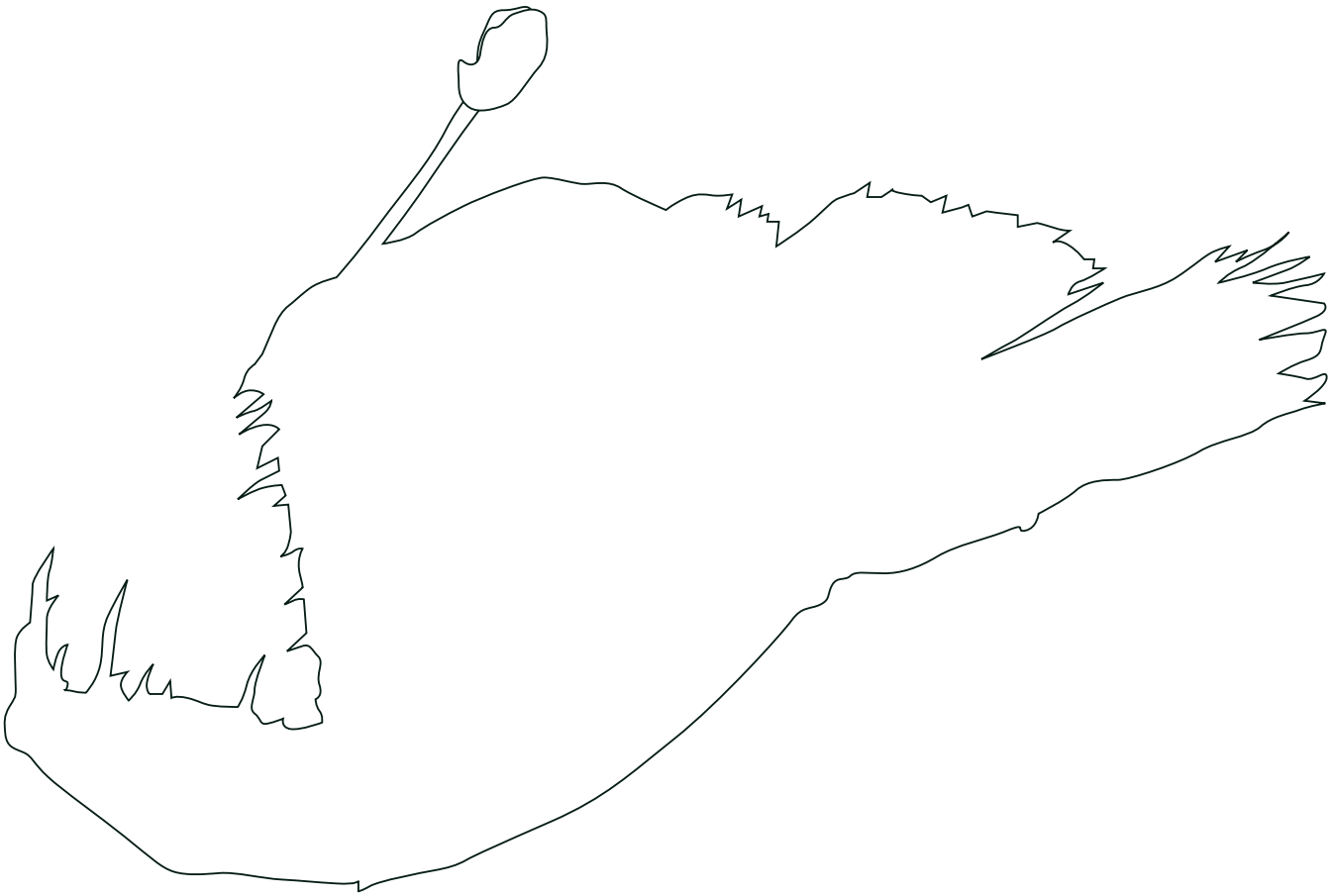


Describe the environment that your animal lives in.	How does your animal use this light?
What parts of your animal are glowing?	What color is the light?

Student Worksheet

TEAM: Deep-Sea Anglerfish

Name: _____



Describe the environment that your animal lives in.	How does your animal use this light?
What parts of your animal are glowing?	What color is the light?

Student Worksheet

TEAM: Stoplight Loosejaw Dragonfish

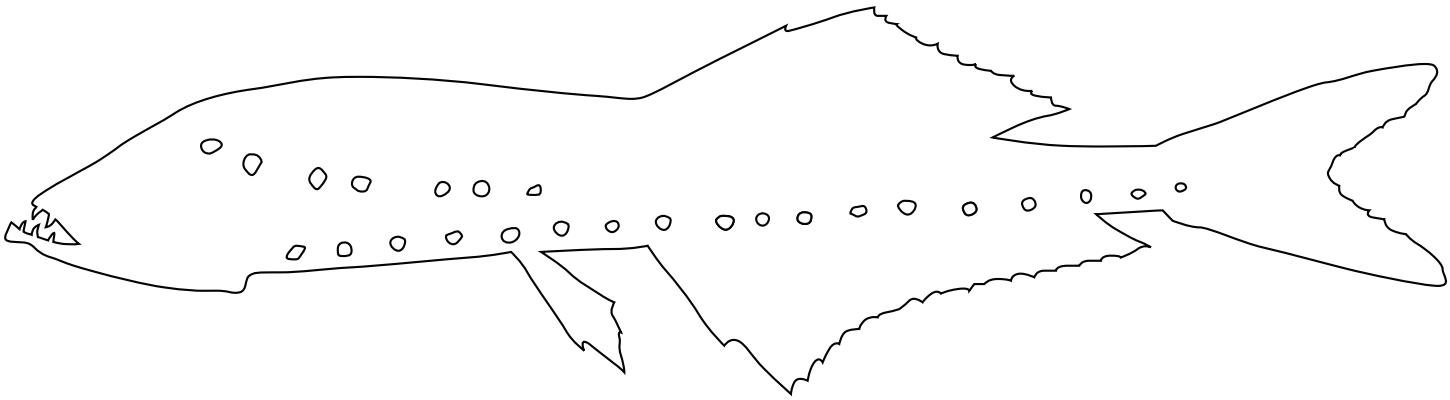
Name: _____

Describe the environment that your animal lives in.	How does your animal use this light?
What parts of your animal are glowing?	What color is the light?

Student Worksheet

TEAM: Bristlemouth

Name: _____

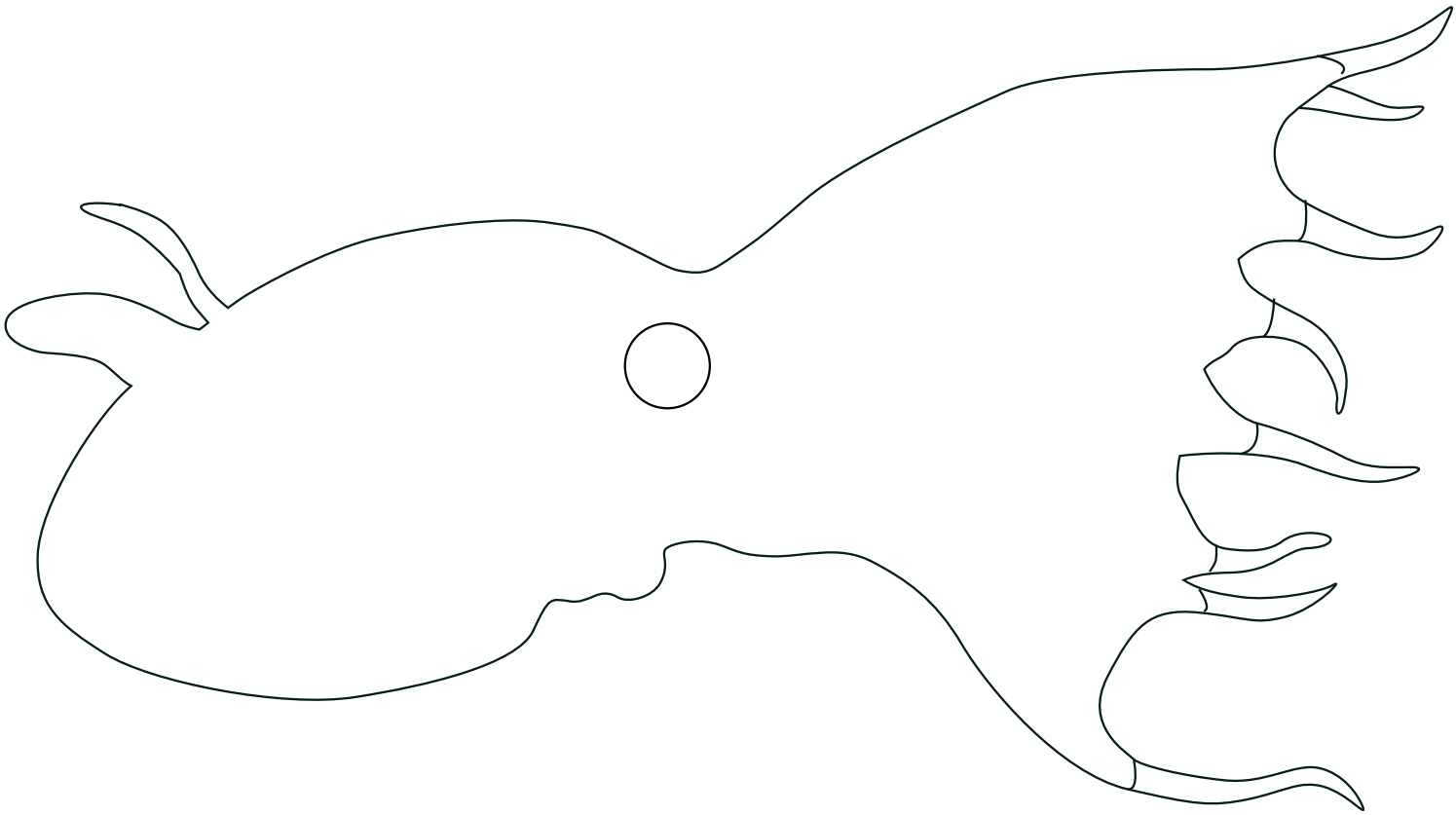


Describe the environment that your animal lives in.	How does your animal use this light?
What parts of your animal are glowing?	What color is the light?

Student Worksheet

TEAM: Vampire Squid

Name: _____



Describe the environment that your animal lives in.	How does your animal use this light?
What parts of your animal are glowing?	What color is the light?

Bioluminescence and Environment

OVERVIEW

In these activities, students will understand how bioluminescence can benefit organisms that live in dark environments.

- **Before Your Visit:** Students will explore bioluminescent animals and their environments.
- **During Your Visit:** Students will observe bioluminescent animals and explore how their glowing body parts help them survive.
- **Back in the Classroom:** Students will share their findings and further explore how bioluminescence help animals survive.

NYS Science Core Curriculum

LE 5.1b: An organism's physical features can enable it to carry out life functions in its particular environment.

BACKGROUND FOR EDUCATOR

Bioluminescence — the chemical reaction that takes place in an organism and produces detectable light — can be particularly useful to animals that live in the dark. Scientists have observed organisms using bioluminescence in ways that include:

- Communication: signaling to mates
- Feeding: attracting prey with glowing body parts, making prey visible
- Self-defense: counter-illumination (camouflage), illuminating predators in order to attract animals that may attack those predators, startling predators, distracting predators, acting as a warning signal

BEFORE YOUR VISIT

Discussion: Bioluminescence

Have students look at images of bioluminescent organisms in their environments. (You can refer to the exhibition floor plan to help you select the organisms). Ask:

- What features do all of these environments share? (Answer: darkness)
- What are some of the challenges of living in the dark? (Answers may include: harder to find food, to find a mate, to communicate)
- How might the ability to produce light benefit the organisms that live here? (Answers may include: might help them see better which would be helpful for feeding, mating, or outsmarting predators)
- What might be some of the drawbacks of glowing? (Answers may include: you are making it easier for others to see you, which may attract predators)

Plan how your students will explore *Creatures of Light.* Since the exhibition will be dark, we recommend that you and/or your chaperones use the guided explorations in Teaching in the Exhibition to guide your students through the exhibition.

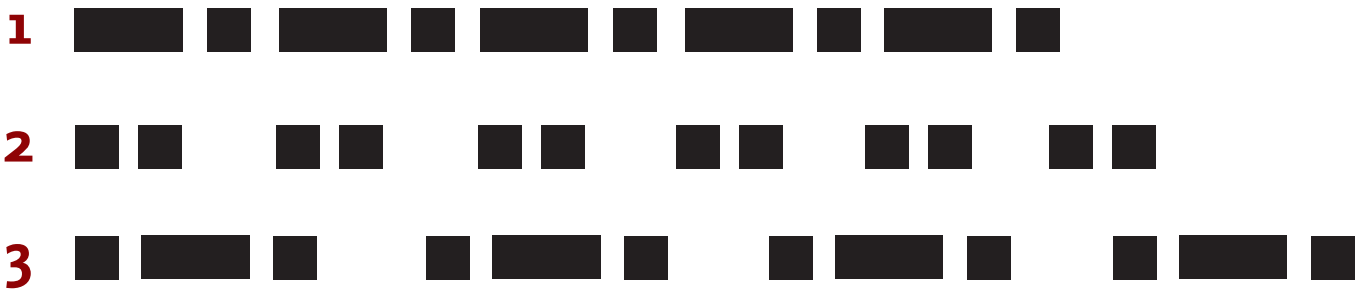
Before your visit, distribute copies of the **worksheets** to students and review them together. Tell students that they will be filling in the worksheets *after* the exhibition.

Activity: Communication: Fireflies

Students will try to communicate with flash patterns that resemble those used by fireflies.

Materials: Flashlights, Flashcards with pictures of different fireflies and their coding sequences (indicate the top of the card)

Divide your class into six or nine groups and give each group a flashlight and flashcard with one of the codes provided here. There must be at least 2 groups with each code.



Explain that:
- each group's code will match up with one other group's (their "mate")
- a dot indicates a short flash and a dash indicates a long flash (demonstrate)

Give each group a few minutes to practice their codes.

Then give the groups five minutes to try and find their mates using only their flashlight codes. Afterwards, discuss the challenges of communicating only with light. Ask:

- Why did some groups succeed and others not? (Answers may include: its easier to find each other if you are close by or there isn't a lot of light interference, the simpler the signal, the easier it is to spot it)
- What made it hard to communicate? (Answers may include: hard to understand the signal with so many others signaling at the same time, hard to tell if the flash was long or short)

DURING YOUR VISIT

Creatures of Light: Nature's Bioluminescence

4th floor (45 minutes)

Before entering, remind students that they should be on the lookout for which bioluminescent organism they might like to focus on. Refer to the guided explorations found in the Teaching in the Exhibition section of this guide as you progress through the exhibition.

Milstein Hall of Ocean Life

1st floor (20-30 minutes)

Have students visit the Deep Sea Ecosystem on the upper level of the hall. Break students into groups and have them discuss how bioluminescence helps different animals survive. Ask them to note similarities and differences between organisms, and write down their observations. Students may also want to think about the challenges that that an organism would face if it weren't bioluminescent. Have students complete both sections of their worksheets here.

BACK IN THE CLASSROOM

Activity: Create a Classroom Mural of Bioluminescent Creatures

Have students give a short presentation on one of the bioluminescent organisms that they learned about at the Museum. Have them include information about its habitat, why bioluminescence is useful in that environment, what color it displays, and how bioluminescence helps it survive. You may want to assign students interested in the same animal to work in teams. Afterwards, students can use the presentations to create a classroom mural.

Activity: How Does the Stoplight Loosejaw Dragonfish Spot Prey?

In this activity, students will look through different colored lenses to see if it confers an advantage in spotting prey. (The stoplight loosejaw dragonfish uses its pulsing red light — the "stoplight"— to spot a red shrimp, then catches the shrimp in its oversized and extendable "loose" jaw. Since this fish is almost the only deep-sea animal to both produce and see red light, it spies the shrimp. But the shrimp can't detect the fish's red light… so it gets eaten!)

Materials:

- Sheets of blue- and red-tinted plastic
- Hole punch
- Red, blue, and black construction paper (one sheet each of red and blue paper, two black sheets)

Using the hole punch to make five sets of colored dots (20 each in blue, red, and black). Scatter all the dots on a square yard of black material and have students take turns as predators. Each predator gets 15 seconds to pick up dots, one at a time. As:

- How many dots did each predator collect?
- Which color dot was captured most often? Why do you think that was?

Repeat the activity, this time with one predator looking through red-tinted plastic, another looking through blue-tinted plastic and the third using no filter. Compare and discuss the results.

Activity: How Does the Hatchetfish Defend Itself?

In this activity, students will see what challenges this method of camouflage creates for predators. (The hatchetfish adjusts the light on the rows of light organs on the underside of its body to blend in with the faint light from above. This helps to hide it from predators lurking below.)

Materials:

- Wrapping paper with a two-colored pattern
- Plain wrapping paper (1 roll in each of the colors that match the colors in the pattern)
- Scissors
- Tape

Cut a large sheet of the patterned paper; this will be the "environment." Cut 10 fish shapes out of each of the 3 types of paper. Attach the fish to the "environment," matching its shape to the background as well as possible.

Attach this to the wall of your classroom. Break the classroom into two groups and give each group 15 seconds to "hunt" in the habitat. (Have them stand a few feet away).

After the hunt, ask:

- How many fish did your group find?
- What color fish did you find the most of?
- Was it harder to find the patterned fish? Why?

Student Worksheet

Use this sheet to record your observations about some of the bioluminescent animals that you saw in the Museum today.

Pick a bioluminescent animal from the *Creatures of Light* exhibition.

Draw it here.

What is the animal's name?

What part of its body lights up?

How does bioluminescence help the animal?

Why would it be harder for the animal to survive of it weren't bioluminescent?

Pick the bioluminescent animal from the Deep Sea Ecosystem in the Milstein Hall of Ocean Life.

Draw it here.

What is the animal's name?

What part of its body lights up?

How does bioluminescence help the animal?

Why would it be harder for the animal to survive of it weren't bioluminescent?

Relationships for Survival: The Role of Bioluminescence

OVERVIEW

In these activities, students will focus on ecological relationships and investigate the many ways that species might interact using bioluminescence.

- **Before Your Visit:** Students will explore the variety of relationships between creatures that glow.
- **During Your Visit:** Students will observe and collect information about ecological relationships between species.
- **Back in the Classroom:** Students will explore how these different relationships affect survival.

NYS Living Environment

Standard 7.1c: In all environments organisms interact with one another in many ways. Relationships amongst organisms may be competitive, harmful or beneficial.

BACKGROUND FOR EDUCATOR

Bioluminescent species interact with other creatures in many ways, such as through competition, predation, attraction, or an ongoing symbiotic relationship such as mutualism, commensalism, or parasitism. All ongoing ecological relationships, even parasitic or predatory ones, have evolved over long periods of time and are integral to an ecosystem's balance and stability.

BEFORE YOUR VISIT

Activity: How do bioluminescent organisms interact with others?

Part 1: Warm-up Discussion
Ask students:

- In what environment would bioluminescence, or the ability to glow, be particularly useful to animals? (Answers may include: nighttime, darkness, underground, the deep sea)
- What activities do you think an organism would use bioluminescence for? (Answers may include: communication — signaling mates; feeding — attracting prey with glowing body parts, allows predators to see their prey; self-defense — counter-illumination (camouflage), illuminating invading predators to attract the attention of other predators, startling attackers, distracting predators, warning signal)

Plan how your students will use the *Creatures of Light* student worksheets. Since the exhibition will be dark, we recommend that students take mental notes in the exhibition and record their observations afterwards.

Before your visit, tell students that they will be collecting information on the relationships between different species and filling in their worksheets *after* the exhibition.

Part 2: Ecological Relationships of Bioluminescent Creatures
Review students' knowledge of ecological relationships by asking them to the ways that different species in the same habitat interact. Write their answers on the board (e.g. Species A might eat Species B, Species A might use Species B's discarded shell for shelter).

Ask the students to name some of these interactions (e.g. predation, parasitism). If those terms are not on the list, ask if anyone can define predation, parasitism, and symbiosis.

Note: If you haven't covered these terms yet, this would be an ideal opportunity to teach them to students, along with mutualism and commensalism.

Write "symbiosis" on the board. (Symbiosis is a long-term interaction between different species that interact in close proximity.) Underneath, write these symbols in three rows: +,+; +,0; and +,-. (They represent the three main types of symbiosis.) Ask the students to name the term for a symbiotic relationship that benefits both species. (mutualism, +,+) What about one that benefits one species while the other species is not affected? (commensalism, +,0) Finally, what about a symbiotic relationship that benefits one species and harms the other? (parasitism, +,-)

As a class, see if you can classify all of the interactions brainstormed in Step 1 as mutualistic, commensal, parasitic, or none of the above. Then point out the additional ecological relationships NOT generally considered to be symbiotic: predation (not a long-term relationship as one species is eaten), competition (not considered to be a direct interaction between species as the focus is a fight over an external resource) and reproduction (not an interaction between species, but between individuals of a species; not always a long-term relationship).

Part 3: Wrap Up
Have students read the content, "Deep Sea Diorama: Lights in the Dark" on the Museum's Milstein Hall of Ocean Life website. (amnh.org/exhibitions/permanent/ocean/02_ecosystems/02h3_darklights.php)

Have students add any inter-species relationships they learned about in the article to the list on the board.

Have students list two bioluminescent species that they'll try to find during their visit to the Museum, and add it to their data sheet.

DURING YOUR VISIT

Creatures of Light: Nature's Bioluminescence
4th floor (45-60 minutes)
This exhibition is too dark to read or write easily, so we recommend that students make mental notes of the organisms and the relationships they observe. Distribute the student worksheet afterwards, in the Hall of Ocean Life.

Tell students that they'll be exploring and observing ecological relationships between species (on land and in the ocean). They will be collecting information about the relationships between species from different media in the exhibition (e.g. text panels, models, iPad stations, movie). Explain that they'll be writing down their observations after they leave the exhibition. Have students watch the "In the Deep Sea" video at the end of the exhibition.

Milstein Hall of Ocean Life
1st floor (30 minutes)
Find a quiet place in this hall, preferably in front of the Deep Sea Ecosystem because it has many of the organisms found in the *Creatures of Light* exhibition. Distribute the "Ecological Relationships" worksheet. Have them list the pairs of species they observed interacting in *Creatures of Light*, and record the type of interaction on the worksheet. Encourage them to try to remember as many relationships between organisms as possible.

Note: This part can be done as a group discussion, with students writing the examples as they're offered up.

Then have students explore the Milstein Hall of Ocean Life, observe other species that glow in the dark, and add these species and their relationships to the worksheet. They may also add species that don't glow if they can describe how they interact with bioluminescent organisms.

BACK IN THE CLASSROOM

Activity: Exhibition Wrap-Up

Divide students into groups and have them reflect on what they learned on their trip to the *Creatures of Light* exhibition and the Milstein Hall of Ocean Life. Ask them to answer the following questions in their notebooks, supporting each answer with examples:

- What environments do organisms that glow live in?
- What functions does bioluminescence serve for the various species that use it?
- How does bioluminescence help creatures survive in specific environments?

Afterwards, have students share some of their answers with the whole class.

Ecological Relationships Worksheet

ANSWER KEY

1. List some species that you observed in the *Creatures of Light* exhibition in the first column. Then record your observations in the column that describes the kind of relationship it has: How do different species use bioluminescence? For what purposes? What kinds of relationships do they form with other species that glow?
2. List some additional species that glow that you observed in the Milstein Hall of Ocean Life. You may also add species that don't glow if you can describe how they interact with bioluminescent species.

Species	Purposes of Bioluminescence					
	Predation	Commensalism	Attraction	Defense	Mutualism	Parasitism
Pony Fish		*Fish gets a way to attract mate. Bacteria get a place to live, but they can survive just as well outside the fish…*	*Male flashes to attract females*			
Deep-sea Shrimp				*Spits out bioluminescent saliva when threatened*		
Fireflies	*Female firefly sees male of different species flashing, and attacks*		*Female is attracted to male firefly flashing for reproduction*			
Fungus gnat	*Attracts prey (insects) into sticky lines and eats*					
Hatchet-fish				*Camoflauge – blend in with above*		

continue on next page >

Species	Purposes of Bioluminescence					
	Predation	Commensalism	Attraction	Defense	Mutualism	Parasitism
Stoplight Loosejaw Dragonfish	*Attracts prey with lure*	*Fish gets a way to attract mate. Bacteria get a place to live, but they can survive just as well outside the fish...*				
Honey Mushroom						*Honey mushroom living on and eventually killing trees*
Dinoflagellates				*Flash to startle predators, or expose invading predators*		
Flashlight Fish	*Attract prey*			*Confuse predators*		

Understanding Bioluminescence & Fluorescence

OVERVIEW

Students will learn how bioluminescence and fluorescence work, and how organisms use light to survive and reproduce.

- **Before Your Visit:** Students will be introduced to the phenomenon of bioluminescence and prepare for their Museum visit.
- **During Your Visit:** Students will collect data about bioluminescent and fluorescent organisms.
- **Back in the Classroom:** Students will share their findings and explore how scientists study bioluminescent and fluorescent organisms.

BACKGROUND FOR EDUCATOR

Bioluminescence is visible light generated by a living organism through a chemical reaction. One type of chemical, luciferin, is acted on by another type of chemical, an enzyme called luciferase, in the presence of oxygen (other molecules are sometimes involved). The energy produced by this reaction takes the form of photons, or units of light.

Fluorescence is another process that can cause things to emit light. Things that fluoresce absorb light of shorter wavelength and re-emit it as longer-wavelength light. This changes the color, such as from blue to red.

Organisms use a variety of body parts to emit light in different colors and for different purposes. In a few organisms, both bioluminescence and fluorescence occur.

Major Understandings

LE 1. 1.1b: Learning about the historical development of scientific concepts or about individuals who have contributed to scientific knowledge provides a better understanding of scientific inquiry and the relationship between science and society.

LE 6.2b: Biodiversity also ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries with significant value to humankind. As diversity is lost, potential sources of these materials may be lost with it.

BEFORE YOUR VISIT

Activity: Why Do So Many Organisms Glow in the Dark?

Part 1: Observe Organisms That Glow in the Dark
Begin the lesson with a short discussion. Ask:

- Do you own anything that glows in the dark? (Answers will vary.)
- What is meant by the term "glow in the dark"? (Answers will vary.)
- What makes something glow in the dark? (Accept all answers.)
- What are some examples of living organisms that also glow in the dark? (Answers will vary.)

Project two short videos of organisms found in the deep sea and how scientists study them:

BBC Planet Earth: Deep Ocean Creatures (4:35)
youtube.com/watch?v=mrSu65Bb9X4im

Monterey Bay Aquarium: Discover Alien Life Forms (1:27)
montereybayaquarium.org/videos/Video.aspx?enc=oZZ+8rD1FkYIbAdCXUUyqw

Plan how your students will explore *Creatures of Light* using the student worksheets. Since the exhibition will be dark, we recommend that students record notes after the exhibition.

Before your visit, distribute copies of the **two worksheets** to students and review them together. Tell students that they will be filling in the worksheets after the exhibition, but should use the questions on the worksheets as a guide.

Have students write down the things they recognize. As students watch the first video, read this aloud to them:

> *The world underwater is very different than the world we live in. In the deep sea, where it is perpetually dark, the only glimmers of light come from living things. This is a world full of bioluminescence creatures. Here, most of the animals light up as they travel, hunt, and mate.*

After the video, ask:

- How do you think scientists study these organisms? (Accept all answers.)
- Why do you think these organisms would light up? (Accept all answers.)

Part 2: Prepare for Your Museum Visit
Divide your class into groups of two or three. Distribute the "Preparing for *Creatures of Light*" worksheet to each student. (You can also project the *Creatures of Light* exhibition map.)

Tell students that the goal of the visit is to observe these organisms and learn how and why they light up. Ask each group to pick two or three sections to explore in the exhibition and come up with their own questions. Tell students the space will be too dark to take notes. Review the guiding activities in advance.

Optional Activity: Demonstrating Fluorescence of Chlorophyll

Use this classroom experiment to introduce students to the concept of fluorescence. See the full activity at the end of this PDF.

DURING YOUR VISIT

Creatures of Light: Nature's Bioluminescence

4th floor (45 minutes)

Review the second part of the "Preparing for *Creatures of Light*" worksheet with students. Encourage them to use all their senses to explore what life in darkness might be like. Have them use the worksheet to guide their observations in the exhibition. Tell them that they will regroup in the Milstein Hall of Ocean Life to record their observations.

Milstein Hall of Ocean Life

1st floor (30 minutes)

This hall provides a great opportunity to reinforce key ideas of the *Creatures of Light* exhibition as well as provide a space for students to sit and record notes about what they learned.

BACK IN THE CLASSROOM

Activity: Exhibition Wrap Up

Have students gather in small groups to share their notes from the visit about how and why so many organisms in the open ocean produce light.

Then as a class, have students make a list of ways we benefit from the biodiversity of the ocean. Ask: How many of the organisms in the exhibition do you think we benefit from? (Accept all answers.)

Activity: How do scientists study bioluminescence and fluorescence?

Working in small groups, have students read one of the scientist profiles (Edith Widder or Osamu Shimomura; see the end of this PDF). Then have them use the following questions to guide their reflections, and share their thoughts with the rest of the class.

Reflection Questions

1. What skills do you need to do this type of research?
2. What tools do you think scientists use in this kind of research? Why?
3. What is the best vehicle for observing deep-sea life? Why?
4. Describe the benefits to society of studying bioluminescence and fluorescence.
5. Would you be interested in working with the scientist you read about? Why or why not?
6. Defend this statement, using evidence gathered on your trip to the Museum: It is important to protect the biodiversity of bioluminescent and fluorescent organisms.

ONLINE RESOURCES

Science Bulletins: Jellies Down Deep

ez-www.amnh.org/creatures-of-light/videos/jellies-down-deep

Increasingly, marine researchers are finding that there are far more jellies and jellyfish in the world's oceans than previously believed. These creatures may play an unexpectedly large role in ocean ecosystems. This documentary, which was produced by the Museum's innovative multimedia program Science Bulletins, follows scientists at the Monterey Bay Aquarium Research Institute as they retrieve jellies from the deep and features spectacular underwater footage.

Illuminating the Perils of Pollution, Nature's Way

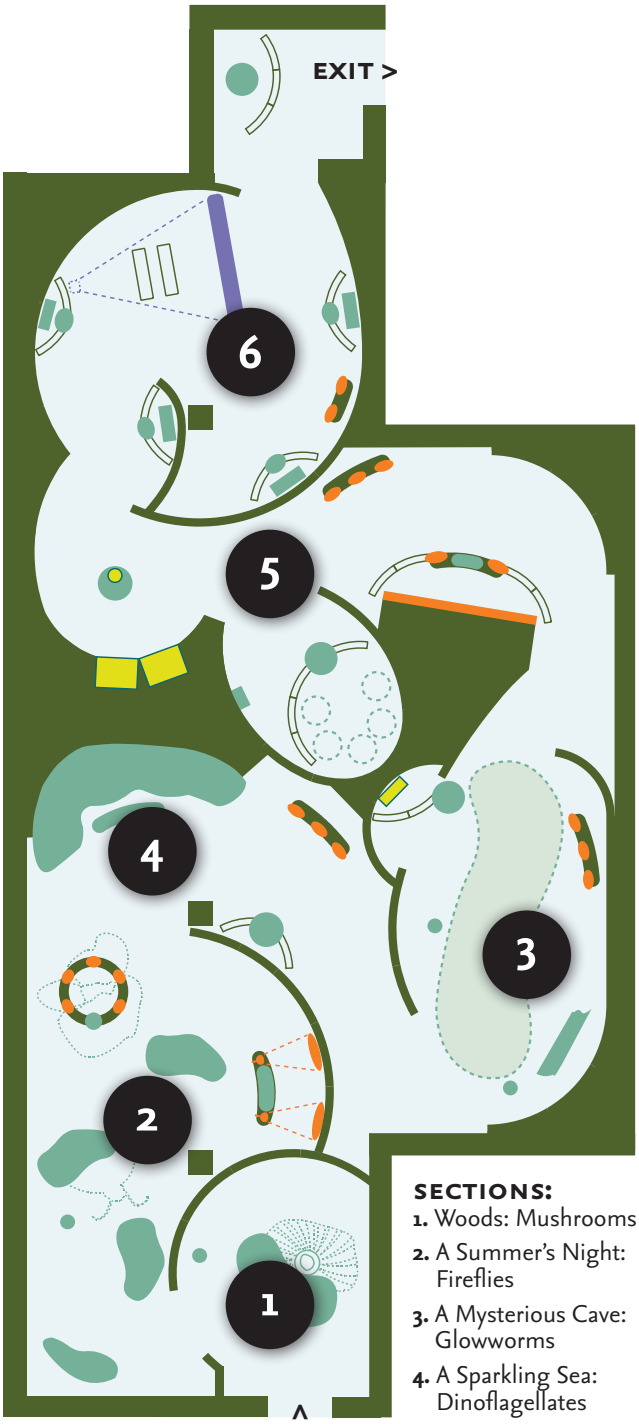
nytimes.com/2011/12/20/science/a-pollution-fight-powered-by-bioluminescent-sea-creatures.html

Natural Light Photo Slideshow: nytimes.com/slideshow/2011/12/20/science/20BIO.html

Edith Widder: Glowing Life in an Underwater World: youtube.com/watch?v=IThAD5yKrgE

Student Worksheet: Preparing for the Exhibition

Working with your team, pick three sections of the exhibition to investigate the question: Why do so many organisms produce light?



SECTIONS:

1. Woods: Mushrooms
2. A Summer's Night: Fireflies
3. A Mysterious Cave: Glowworms
4. A Sparkling Sea: Dinoflagellates
5. Sea Shores: Corals, Jellies, & Fishes
6. The Deep Ocean: Predators & Prey

Why did you pick these sections?

What questions do you have?

IN THE EXHIBITION

Although you can take notes in the exhibition, it will be challenging in the low light. So use all your senses to experience what life is like in the absence of light, and use the following activities to guide your observations.

Investigate two or three organisms from your sections that use bioluminescence or fluorescence.

Read and engage with iPads to learn more about how bioluminescence and fluorescence work.

Observe what part of the organism produces light.

Reflect with your team on how the process of emitting light might benefit the organism.

Watch the Deep Ocean video.

Think about what it must be like to work in the deep ocean.

Student Worksheet: At the Museum

1. *Creatures of Light* exhibition

Record information about three organisms that you observed in the exhibition.

Name of Organism	What part of the organism lights up?	Does it use bioluminescence, fluorescence, or both?

What is bioluminescence?

How might bioluminescence benefit organisms?

Where would you want to visit and why?

2. Milstein Hall of Ocean Life: Deep Sea Ecosystem

Observe the diorama and describe what you see.

Sketch an organism and label the parts that light up.

Working with your team, find five different organisms that use light.

Name of Organism	What part of the organism lights up?	Does it use bioluminescence, fluorescence, or both?

ACTIVITY

Demonstrating Fluorescence of Chlorophyll

Use this classroom experiment to introduce students to the concept of fluorescence.

Materials per Group:

- flashlight
- 100 g spinach
- ethanol
- coffee filter
- two 250 ml beakers

Put students in groups of three to four. Alternatively, you can also demonstrate this for the class.

1. Chop about 100 grams of spinach leaves into small pieces, and put into 250 ml beaker with 75 ml of ethanol.
2. Let the jar stand for 20 minutes.
3. Then pour through a coffee filter into a clean clear beaker.
4. Shine a flashlight on one side of the jar, and observe. Ask students to record their observations. (Students should observe a dark red fluorescence.)
5. Tell students that the red color is a result of fluorescence, and that they'll learn more about fluorescence in the exhibition.

Background for Educators and Students:

- Fluorescence is one way some organisms light up.
- In fluorescence, electrons of certain type of molecules become excited when they absorb high-energy light from an outside source. As the electrons calm down, the energy absorbed is released as lower-energy light. Since light fuels fluorescence, the glow is more intense when they are under high-energy radiation, like ultraviolet light.
- One of the most common fluorescent molecules in nature is chlorophyll, the green pigment found in plants. Leaves are green when lit by the Sun because they reflect the green light wavelengths. Chlrophyll absorbs mostly blue and red light wavelengths, which are the driving energy of photosynthesis. The energy of light is measured as wavelength: the shorter the wavelength, the stronger the energy of the light. When illuminated by ultraviolet light, the plant pigment glows red, which is lower in energy. The missing energy or difference in energy between the high-energy of the UV light and the lower-energy red light is released as heat energy A less intense fluorescence can be produced using a flashlight. In nature, plants fluoresce with daylight but this phenomenon can be seen only with special instruments.

SCIENTIST PROFILE

Edith Widder

Bioluminescence Advocate

In 1984, as she was testing a new diving suit, marine biologist Edith Widder descended 880 feet (268 meters) into the ocean and was overwhelmed: A display of blue bioluminescent light burst forth before her. Thus began her obsession with creatures of light!

Filming in the Deep

So that others could appreciate the amazing variety of sea life, Widder began shooting videos from inside a submersible. Because the vehicle's noise and bright lights tended to scare away creatures, she developed a less obtrusive device.

An Eye in the Sea

This device, called "Eye-in-the-Sea," sits on the bottom of the ocean and sends images to the surface. It includes a camera that uses red light, invisible to most sea creatures. And it incorporates an epoxy "jellyfish" with programmable blue lights, seen here, to attract animals.

Success

The device's first foray in the Gulf of Mexico in 2004 was a triumph, capturing on film a previously unknown squid species. In a venture 3,000 feet (914 meters) down to the floor of the underwater Monterey Canyon off California's coast, a more advanced camera recorded many more species. The explorations continue.

A New Effort

Widder is working on a method to estimate pollution levels: She adds bioluminescent bacteria to lagoon sediment and measures how fast the bacteria's light diminishes.

SCIENTIST PROFILE

Osamu Shimomura

In 2008, scientist Osamu Shimomura won a Nobel Prize in Chemistry for discovering green fluorescent protein (GFP). But he hadn't actually been looking for GFP. He had been trying to purify the bioluminescent components of the jellyfish *Aequorea victoria*.

No Light?

In the early sixties, intrigued by the jellyfish's green luminescence, Shimomura managed to prepare a solution with the luminescent tissues of 10,000 jellyfish! He realized that the light wasn't produced by a typical luciferase/luciferine reaction but probably by a special protein. He tried many times but - unlike other bioluminescent reactions he knew – the solution did not light up outside the jellyfish. What was missing?

Strong Light!

By chance, he added a small amount of seawater to the solution, and was rewarded with what he called an "explosively strong" light! He realized that for the jellyfish's bioluminescence to work, it needed calcium ions from the seawater. He purified the luminescent protein and called it aequorin.

Green, Not Blue

Strangely, in the lab, the bioluminescent light was blue, not green as in the jellyfish. Upon examination, Shimomura found an additional molecule, Green Fluorescent Protein. The GFP absorbed the blue bioluminescent light produced by the aequorin and emitted it as lower-energy green light…and the puzzle was solved!

A Major Contribution

Shimomura's discovery, GFP, has been adapted by other scientists to become a vital tool in biological research.

Colorful Tool Kit

Naturally occurring fluorescent proteins have become important tools for researchers as they investigate questions like how stem cells specialize or how brain cells communicate. GFP—green fluorescent protein—was the first to be adapted for broad scientific use. Then, red fluorescent proteins from corals were adapted. Now fluorescent proteins of many colors can be expressed in living cells, where they literally illuminate biological processes.

Elementary school									
Standard	**Major understandings**	Introduction	A Summers Night	A Mysterious Cave	Blue Lagoon	Corals On Fire	A Different Light	Live Flashlightfish	The Abyss
	1.1d Non-living things can be human created or naturally occuring.						x		
	3.1a Each animal has different structures that serve different functions in growth, survival and reproduction.	x	x	x	x	x	x	x	x
	3.1c In order to survive in their environment, plants and animals must be adapted to that environment.		x	x	x	x	x	x	x
	5.1b An organisms physical features can enable it to carry out life funtions in its particular environment.	x	x	x	x	x	x	x	x
	6.1a An orginisms pattern of behavior is related to the nature of that organisms environment including.... the physical characteristics of the environment	x	x	x	x	x	x	x	x
Middle School									
Standard	**Major understandings**	Introduction	A Summers Night	A Mysterious Cave	Blue Lagoon	Corals On Fire	A Different Light	Live Flashlightfish	The Abyss
LE 4	3.2a In all environments, organisms with similar needs may compete with one another for resources.		x	x					x
	5.1a Animals and plants have a great variety of body plans and internal structres that contribute to their ability to maintain a balanced condition.	x	x	x	x	x	x	x	x
	5.1b An organisms overall body plan and its environment determine the way that the organism carrie sout the life processes.	x	x	x	x	x	x	x	x
	5.1g The survival of an organism depends on oits ability to sense and respond to its external environment	x	x	x	x	x	x	x	x
	7.1a A population consisits of all individuals of a species that are found together at a given place and time. Populations living in one palce fom a community. The community and the physical factors with which it interacts compose an ecosystem		x	x	x				x
	7.1C In all environments, organisms interact with one another in many ways. Relationshipos amongst organisms may be competitive, harmful or beneficial.		x	x	x				x

High School									
standard	Major understandings	Introduction	A Summers Night	A Mysterious Cave	Blue Lagoon	Corals On Fire	A Different Light	Live Flashlightfish	The Abyss
LE 4	1.1b An ecosysytem is shaped by the non living environment as well as its interacting species. That world contains a wide diversity of physical conditions which creates a variety of environments.		x	x	x	x			x
	3.1g Some characteristics give indiviuals an advantage over others in surviving and reporducing and the advantaged offspring are more likely than others to survive and reproduce.		x	x	x	x	x	x	x
	3.1i Behaviors have evolved through natrual selection. The broad patterns of behavior exhibited by organisms are those that have resulted in greater reproductive success.		x	x	x	x	x	x	x
	6.1g Relationships between organisms may be nagative, neutral or positive. Some organisms may interact with one another in serveral ways. They may be in a producer/consumer, predator/prey, or parasite/host relationship.		x	x	x				x