
Living Lights *(Bioluminescence)*

Théa Carina Adumitroaie
3rd Grade, Chino Hills, CA



Outline

- **What and how organisms produce light and to what purpose as well as engineering applications.**
 - **What: an overview of the different luminescent organisms**
 - **How: a short description of various ways of producing bioluminescence**
 - **Purpose: living rewards of bioluminescence**
 - **And a few engineering (more or less) applications**

Bioluminescence

- **Bioluminescence is a phenomenon where light is emitted from a living organism.**
 - **Bios means life in Greek.**
 - **Luminescence means “the emission of cold light.”**
- **Robert Boyle (1660) used a vacuum pump he built to demonstrate that the luminescence of fungi requires air.**
- **Benjamin Franklin (1747) thought bioluminescence is an electrical phenomenon, but changed his opinion when he found out that seawater light can be filtered with a cloth.**

Distribution of Bioluminescence Among Living Creatures

- **People know bioluminescence from fireflies, but in fact there are many more organisms that produce light and habit the oceans (over 39 species).**
- **There is no clear pattern in the way luminous organisms are scattered on the “Tree of Life”.**
 - **For example, one species is luminous while closely related species is not.**
 - **Most of the bioluminescent organisms are marine dwellers who live primarily in regions of the ocean that don't get much sunlight: the twilight zone [between 700 feet and about 3,300 feet deep] .**
 - **The non-marine creatures are so few we can list them all: fireflies, beetles, earthworms, millipedes, glow worms, limpets (water snails), snails, and luminous mushrooms. (There are no luminous "flowering" plants, birds, reptiles, amphibians or mammals.)**

Insects

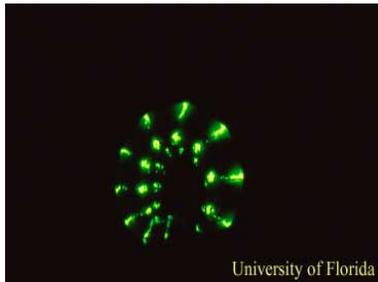


Firefly

- Firefly is not a fly at all, it is a beetle.
- Both adults and larvae are capable of glowing and even firefly eggs glow!
- Not all bioluminescent beetles are fireflies
- The firefly "light" is extremely efficient - about ten times more energy efficient than a light bulb

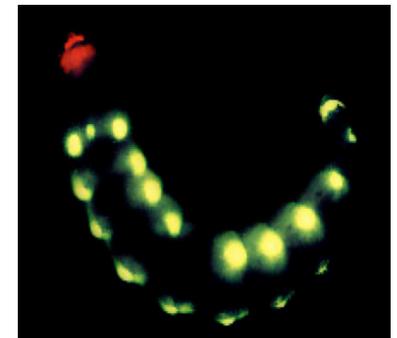


Firefly swarm



"Glow-worm" curled and glowing

- Other species of beetles have bioluminescent females that appear to be larger versions of the larva stage.
- Glowing spots along the females body resemble the windows of train cars internally illuminated in the night, they are often referred to as "railroad worms."
- Two colors! the body glows green, while the head glows red
- This family is different from fireflies which may also be called "glow-worms" in its larval stage.



Railroad worm



New Zealand glow worm

- Before a short adult life as a fungus gnat (small fly), larvae spend months as carnivorous glow worms in caves or sheltered areas using light as a lure.
- From its nest on a cave ceiling, the glowworm dangles several dozen "fishing lines," each studded with evenly spaced, sticky droplets of mucus, which can catch food



Threads with droplets of mucus

More Insects, Worms & Myriapods

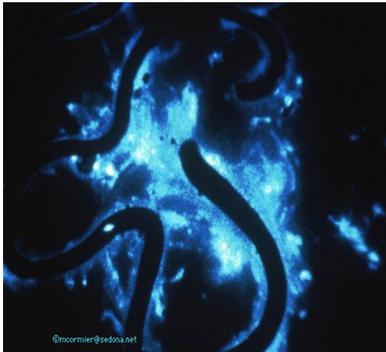


Click beetle with glow lights

- Click beetles make a click noise as they spring to turn over from their back.
- Some click beetles create bioluminescence on two glowing spots, which creatures mistaken to be “eyes,” and stay away from the bioluminescent beetle.



Tropical luminous click beetle



Earthworms

- Tens of earthworm species from all over the world can release a sticky, glowing slime to surprise predators.
- These earthworms are usually seen after rainfall, when the ground is full of water and forces the worms to seek high ground.



Luminous earthworm



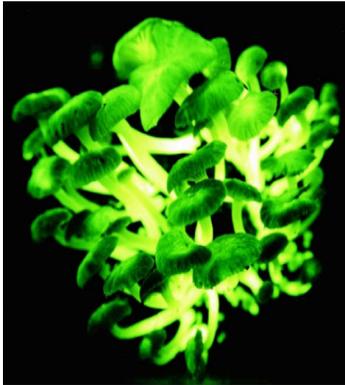
Millipede
2/28/10

- This is a small millipede found in California and it is the only millipede known to be bioluminescent
- Used as “warning luminescence”
- The whole insect lights up at night in a continuous white glow.



California millipede

Foxfires and Milky Seas



Glowing mushrooms from Brazil

- Foxfire is a soft glow or light coming from the leaf-covered ground or dead wood sometimes seen at night in the forests
- The luminescence can be caused by as many as 71 different species of fungi that feed on rotting wood



Bitter oyster fungus



Jack o'Lantern

- The Jack o'Lantern mushroom, has an orange to yellow gill (like the pumpkins) that is poisonous and its bioluminescence can only be seen in low light conditions when the eye becomes used to the dark.
- The whole mushroom doesn't glow — only the gills do.

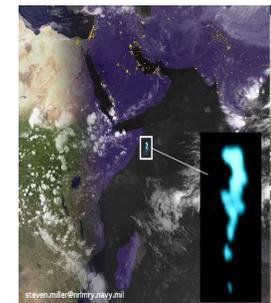


Glowing Jack o'Lanterns



Dinoflagellate

- Some species of plankton called dinoflagellates glow blue light when disturbed.
- Tides, storms, swimming marine life and passing ships can cause large numbers of these plankton to produce light simultaneously.
- Dinoflagellates are responsible for the phenomenon known as the milky sea, which causes the ocean to glow. In some cases, this glow is so bright that it interferes with marine navigation.

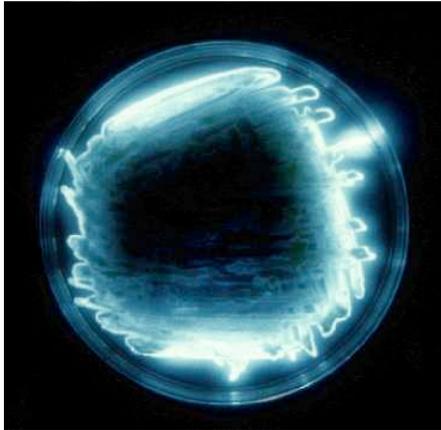


Milky sea in the Indian Ocean

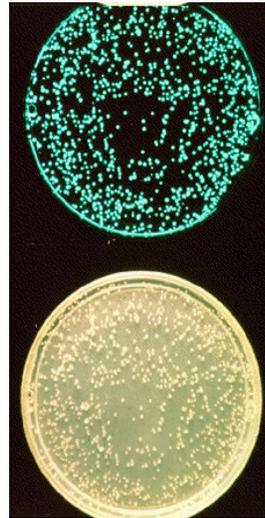
Producing Bioluminescence



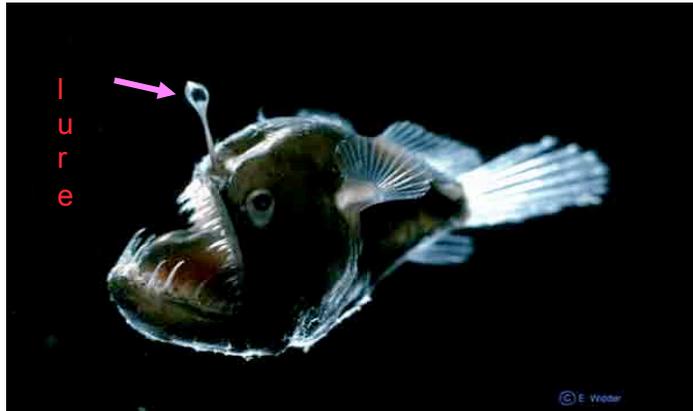
Cookie-cutter sharks



Photobacterium



- **Two ways :**
 - **chemical reaction (compounds react together and produce a glow)**
 - **light producing and light sensitive proteins (very complicated substances)**
- **Some (cookie-cutter shark, most squid) can have these substances in their own bodies**
- **Others (fish, two types of squid) host in the light emitting organ (photophore) bioluminescent bacteria**
- **In order to turn the lights on and off animals can pull their light organs into their bodies**
- **Some cover them with pieces of skin similar to eyelids.**



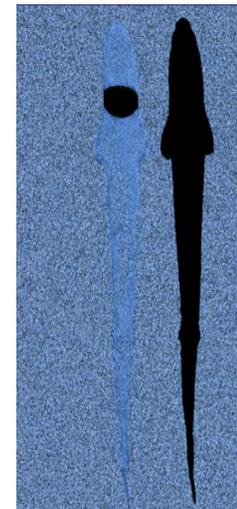
Black Devil Angler Fish

Bioluminescence: What is it good for?

- **Communication:** Fireflies flash in patterns at one another
- **In deep waters bioluminescence is a major source of light for the marine animals and this helps them to feed, fetch food, and scare predators.**
 - **Finding prey:** in the “twilight zone” some fish species use their light to locate food.
 - **Luring prey:** the angler fish uses a glowing lure to attract other fish; firefly squid has light organs all over the body.
 - **Escape/Self-defense:** to confuse predators, some squid can release a cloud of bioluminescent fluid when threatened (like the octopus, which uses ink), others use a bright flash to blind them.
 - **Fireflies, glow-worms light up also to warn bats that they taste bad**
- **Disguise:** some species produce spots of light on their undersides, which allow them to blend in with the light from above or appear smaller
- **Burglar-alarm:** if a small fish starts feeding on the plankton, the disturbed plankton flash or light up a glowing trail that leads right to their attacker. It is like a scream for help to attract bigger predators who can gobble up the attackers.



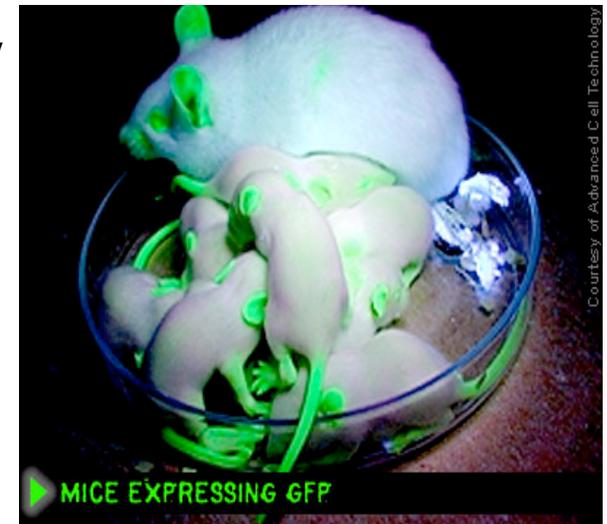
Firefly squid



Cookie-cutter shark disguise

Bioluminescence - Applications

- **Art & Entertainment: Glowing bunnies! (or fish or puppies or ...)**
Not there, but close: “Alba”, the green fluorescent bunny, normally she is completely white with pink eyes (albino). Alba is glowing bright green when (and only when) she is illuminated with blue light.
- **Marine studies: Tiny luminescent organisms that light up when disturbed can be used to study the way animals move through water.**
- **Medicine: Pass the feature to non-luminescent animals to study the evolution of diseases like cancer in live animals (see mice).**
- **Environment: Sensors for detecting poisons – luminescent bacteria that change their level of light emitted when toxic substances are present.**
- **Glowing trees on roads or Christmas trees!**



THANK YOU!

References

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