**Bioluminescence of deep-sea fish –**

 **how light is generated 40,000 leagues under the sea**

**BIOLUMINESCENCE**

Visible light made by living creatures is known as [bioluminescence](http://www.internal.schools.net.au/edu/lesson_ideas/optics/glossary.html#bioluminescence).

Although the firefly is probably the best recognized example of bioluminescence, many organisms in each kingdom exhibit it as well. Among the diverse types of organisms that display bioluminescence are: bacteria, protozoa, fungi, sponges, crustaceans, insects, fish, squid, jellyfish, and lower plants.

On land, bioluminescence is rare. By contrast, in the oceans, bioluminescence is very, very common. In fact, it would be difficult to find any place in the ocean where bioluminescence doesn't exist. There are so many bioluminescent creatures in the ocean because their ability to make light helps them to survive in an environment in which natural sunlight cannot penetrate.

Other than the light from the sky, a major source of light within the sea comes from bioluminescence. In the mesopelagic zone (200-1000 m), approximately 90% of all the animals (fish, shrimp, squid, and gelatinous zooplankton) are bioluminescent. Luminsecent species are not only restricted to deepsea - bioluminescence is also present in fish of coastal waters, [estuaries](http://www.internal.schools.net.au/edu/lesson_ideas/optics/glossary.html#estuary), and those residing in the mesopelagic zone. Basically - wherever light levels may be restrictive or unfavourable.

Light is generated either by the fish itself or from light emitting bacterial cells. Bioluminescence is created from an enzyme called luciferase, which is activated by oxygen (thereby enabling a regulatory control mechanism). It is of interest to note that bioluminescence only occurs in salt water fish as salt is also one of the necessary elements for bioluminescence.

One of the features of biological light that distinguishes it from other forms of light is that it is cold light. Unlike the light of a candle, a lightbulb, a star or even the glow of heated metals, bioluminescent light is produced with very little heat radiation.

Were it not for bioluminescence it is probable that most deepsea fish would be blind. Bioluminescense therefore serves a mulitude of functions - increased vision in otherwise lightless environment, attract a mate, seek out or lure prey closer, frighten off potential attackers and most importantly camoflage.

**"A flash of light in the ocean is a big deal and all eyes are drawn to it"**  (says Edie Widder, an expert on bioluminescence at Harbor Branch Oceanographic Institution in Florida,([NewScientist](http://www.internal.schools.net.au/edu/lesson_ideas/optics/%20http%3A//www.newscientist.com/ns/19990327/lairofthed.html) feature article)).  Most deep-sea fish have large eyes to gather as much of that light as possible. The crucial feature for capturing photons is the size of the pupil, and for some fish the only way to enlarge the pupil without making the eyes too big to fit in the head is to do away with the outer parts of the eyeball and have tubular eyes.  Click [here](http://www.internal.schools.net.au/edu/lesson_ideas/optics/optics_wksht4_p1.html) for worksheet 4 fish eyes - which makes reference to tubular eyes

**EXAMPLES OF BIOLUMINSCENT USE:**

**Vision**

"A flash of light in the ocean is a big deal and all eyes are drawn to it"  (says Edie Widder, an expert on bioluminescence at Harbor Branch Oceanographic Institution in Florida,([NewScientist](http://www.internal.schools.net.au/edu/lesson_ideas/optics/%20http%3A//www.newscientist.com/ns/19990327/lairofthed.html) feature article)).

  The Flashlight fish of the Red Sea uses bioluminescence to see better in the dark sea environment it inhabits.  The light that shines from pockets under its eyes act as headlights for the fish as it swims about. Like most bioluminescent fish, it does not produce its own light but instead harbours bioluminescent bacteria. The bacteria living in this pocket under the eye are always producing light, so this fish has a flap of skin like an extra eye lid to cover the lighted pocket when it doesn't want to be seen.

This [symbiotic](http://www.internal.schools.net.au/edu/lesson_ideas/optics/glossary.html#symbiosis) relationship between fish and bacteria can be used by the fish to help in sight as in the case of this fish, to help keep schools together by making the individual fish easier to see, to make a quick escape from predators by leaving behind a cloud of light, or to hunt.

**Attraction of Prey**

 

The Angler fish is an example of a fish that uses its symbiotic bacteria to make hunting easier. The lighted spot on the end of a rod sticking out of the fishes head is used as a lure. When other fish come close to see what the light source is, they are easily snapped up by the angler's jaws.

**Interspecies Recognition**

**  **

**DRAGON FISH -**  Photo credit (l-r): P J Herring - [University of Bristol](http://www.bio.bris.ac.uk/research/people/partridg.htm), steven haddock - [http://life.sci.uscb.edu](http://lifesci.ucsb.edu/~biolum/), P J Herring - [University of Bristol](http://www.soc.soton.ac.uk/GDD/midbio/PETER.html)

Dragonfish have two sets of light organs on their heads.  A pair of photophores (light emitting organs) located behind the eye emit blue- green light, like other fish. A second light organ beneath the eye emits light in the red part of the spectrum, which is invisible to other fish.  The human eye can just about make out a dim, red glow from two of the dragons, Aristostomias and Pachystomias. However the third dragonfish, Malacosteus niger, emits light that is so far into the red wavelength of light (700nm+) the human eye is unable to detect it.

Most fish do not have a visual pigment which is sensitive to red (705nm) light, yet Dragonfish (Aristostomias, Pachystomias, Malacosteus) possess an additional visual system adaptaion which makes them sensitive to the red light so that only they can see this red light wavelength.

This is a great advantage to this species when competing in the deep blue sea.

Although the red light doesn't travel very far, it allows the Dragonfish to see their prey without alerting the prey or any potentially curious predators; plus it also enables this species to signal each other using the red light and as such it becomes a visual signalling system that is only meant for themselves to see.

A private channel of communication is clearly well worth having - like having a big red flashlight that only others of their kind can see.  They use this private channel to also communicate to each other through the use of flashing lights.

**Camoflage**

In an effort to try and blend into the environment species emit light of a similar wavelength to ambient light levels, thereby disguising the shadowing silhoutte their bodies cause when perceived against an illuminated background. The use of [ventral](http://www.internal.schools.net.au/edu/lesson_ideas/optics/glossary.html#ventral) and [lateral](http://www.internal.schools.net.au/edu/lesson_ideas/optics/glossary.html#lateral) bioluminescent [photophores](http://www.internal.schools.net.au/edu/lesson_ideas/optics/glossary.html#photophores) enables 'countershading' camoflage.



Even in the twilight zone, dimly lit by the last vestiges of sunlight, bioluminescence comes in handy. An animal looking upwards will see the shadowy silhouettes of creatures moving overhead against the dim light above. Some fish and squid make themselves invisible by counterillumination, giving out light of matching intensity from photophores along their bellie

 Photo Credit: [Bryan Keith Sell](http://www.iup.edu/~ZZFG/biolum1.html), undergraduate of Indiana University of Pennsylvania

The Hatchet Fish live and hide in the down welling sunlight of the Mesopelagic zone (200-1000m) by the use of bioluminescence.  The Hatchet Fish has little "holes" or clusters of ventral photophores and the light emitted by these photophores in conjunction with the odd body features eliminate the fishes silhouette thus providing an effective means of evading predators.

Lights can also confuse would-be predators. "If the prospective prey has the right arrangement of lights, a predator can't work out which end is front and which is back-or which direction it is likely to move in," says Julian Partridge, a biologist at the University of Bristol ([NewScientist](http://www.internal.schools.net.au/edu/lesson_ideas/optics/%20http%3A//www.newscientist.com/ns/19990327/lairofthed.html) feature article).

Within the natural habitat, some species have devised a means of overcoming camoflage mechanisms by the use of coloured filters and when photophores are viewed through the yellowed eye lensed eye, they fluoresce and appear brighter than the background.

Addtionally an even more remarkable mechanism is the use of coloured photophores to make the red and brown animals (which are not usually visible when illuminated by blue ambient light or by the usual blue bioluminscent emission) more conspicuous.

**Information Sources:**

* [Bioluminscence](http://www.hboi.edu/marine/biolum2/biolum.html)
* [Coral Reefs and Bioluminescence](http://www.ocean.udel.edu/courses/mast200/Lec18/Lecture18/sld002.htm) - Powerpoint presentation
* [Chemistry of Bioluminescence](http://lifesci.ucsb.edu/~biolum/chem/)
* [The Bioluminescence Web Page](http://lifesci.ucsb.edu/~biolum/)
* [Deep Sea pages](http://www.bmi.net/yancey/index.html) - Paul H. Yancey Professor of Biology (Whitman College USA)  Website focusing on deepsea fish, their environment and adaptations
* [Extreme Science](http://www.extremescience.com/deepcreat.htm) - An online gallery of Deep Ocean creatures
* [NewScientist](http://www.internal.schools.net.au/edu/lesson_ideas/optics/%20http%3A//www.newscientist.com/ns/19990327/lairofthed.html) - Lair of the dragon - feature article on the dragonfish
* [Bioluminescence - uses in nature](http://www.internal.schools.net.au/edu/lesson_ideas/optics/%20http%3A//www.biology.lsa.umich.edu/~www/bio311/projects/ronney/use.shtml)
* [Bryan Keith Sell](http://www.iup.edu/~ZZFG/biolum1.html) - Glowing Creatures of the sea

* Atema J. et al (ed), **Sensory Biology of Aquatic Animals**, Springer Ltd, London, 1988.
* Douglas R & Djamgoz M (ed) **The Visual System of Fish**, Chapman & Hill, London, 1990.
* Herring P.J et al (ed), **Light and Life in the Sea**, Cambridge University Publishers, Cambridge, 1990.
* Herring P.J (ed), **Bioluminescence in action**, Academic Press, Oxford, 1978.
* Nicol J.A.C, **The Eyes of Fishes**, Clarendon Press, Oxford, 1989.

<http://www.internal.schools.net.au/edu/lesson_ideas/optics/optics_wksht5_p1.html>