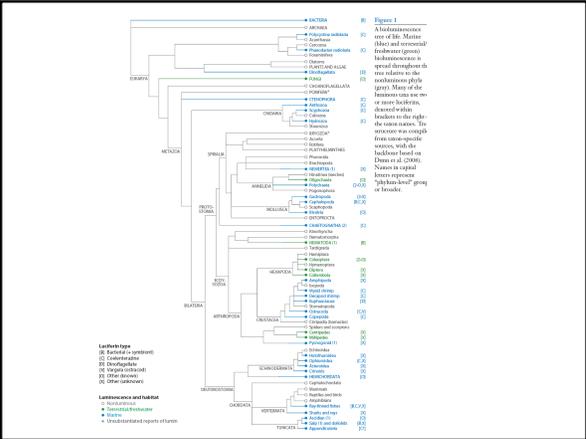


# bioluminescence

- ## Bioluminescence
- Bioluminescence is widespread across most forms of metazoan marine life.
  - Light is typically generated by the organism itself and only rarely due to bacterial symbionts.
  - Light emitters (Luciferins) enzymes (Luciferases)
  - Based on the chemical mechanisms known, luminescence has evolved independently more than 40 times.

- ## bioluminescence
- It serves a variety of functions, both offensive and defensive, even within a single organism.
  - Control of bioluminescence: Chemical and nervous system control
  - a bioluminescent flash can be seen from tens to hundreds of meters away
    - Even a single-celled dinoflagellate 0.5 mm long can send a signal to a large fish 5 m away—the equivalent of a 2 m tall human being able to communicate over a distance of 20 km.

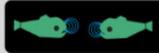


## Functions of bioluminescence

**LEGEND**  
 flash glow prey predator 2<sup>nd</sup> predator

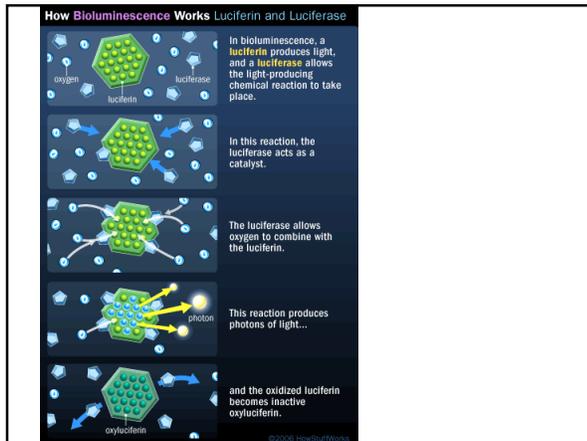
OFFENSE	Function	Examples
	lure prey attract host: bacteria	anglerfishes, siphonophores, cookie cutter shark, squid?
	lure with external light (evaluate habitat?)	sperm whale? megamouth shark?
	stun or confuse prey	squid, headlamp myctophid?
	illuminate prey	flashlight fish, dragonfishes

DEFENSE		startle	dinoflagellates, squid, stern-chaser myctophid
		counterillumination	many: crustaceans, fish, squid
		misdirection: smoke screen	many: crustaceans, polychaetes, scyphozoans, chaetognaths, squids, tube-shoulder fishes, ctenophores, siphonophores, larvaceans?
		distractive body parts	<i>Octopoteuthis</i> squid, brittle stars, polychaetes, siphonophores
		burglar alarm	dinoflagellates, jellies, other?
		sacrificial tag	pelagic sea cucumbers, jellies, polychaetes
		warning coloration (deter settlers)	jellies, brittle stars? (tube worms, clam)



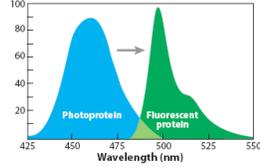
mate attraction/  
recognition  
(swarming cue)

ostracods, *Japetella* octopus?  
lanternfish, flashlight fish, anglerfish?  
syllid polychaetes, others?



## Bioluminescence

- Luciferin/luciferase normally emits at 470 nm (blue)
- Some medusae (cnidarians) emit green light because they have a green fluorescent protein



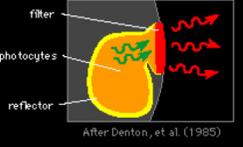
The graph shows two emission spectra. The 'Photoprotein' curve (blue) peaks at approximately 470 nm. The 'Fluorescent protein' curve (green) peaks at approximately 500 nm. The x-axis is labeled 'Wavelength (nm)' with markers at 425, 450, 475, 500, 525, and 550. The y-axis represents relative intensity from 0 to 100.

## Dragon fish red light emission

- Light in the photophore (a light-producing organ) doesn't start out deep red. Initially the light has a short wavelength (red is long-wavelength light). This light is absorbed by a fluorescent pigment inside the photophore, which takes the energy and re-emits it as red light (wavelength = 626 nm). Before it shines out into the sea, the light is also filtered until it has a wavelength of around 705 nm

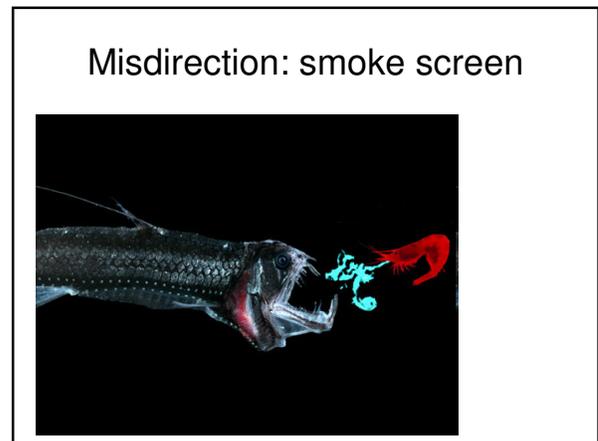


Cross section through the red light organ of *Malacosteus*.  
Photo ©1998 Peter J. Herring



filter  
photocytes  
reflector

After Denton, et al. (1985)

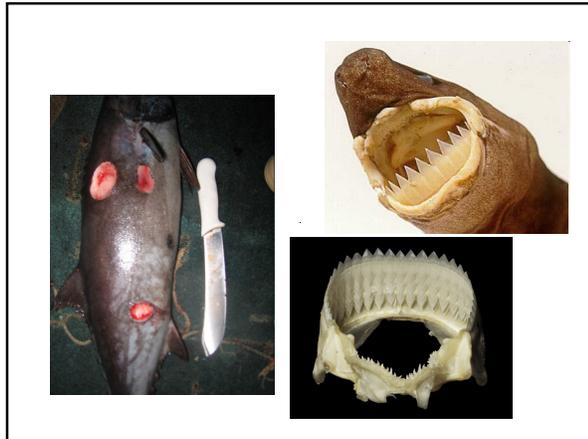


## sacrificial tag

- In this situation, an organism may lose part of its body to a predatory encounter.
- These lost tissues can continue to glow for hours afterward even within the predator's stomach
- the glowing tissue can draw attention to the predator, making it risky to consume bioluminescent prey.
- This is thought to be the selective force driving the presence of so many black- or red-pigment guts in otherwise transparent animals
  - most red and orange pigments absorb blue light

## cookie-cutter shark *Isistius brasiliensis*

- relatively small species feeds by taking bites out of the bodies of much larger fish, cetaceans, and squid
- unclear how it might get close enough to attack these fast-moving prey.
- hypothesized that an optical "flaw" in the counterillumination pattern—a dark band below the mouth—looks like the silhouette of the prey of one of these larger species. When the fish or squid draws near to attack this apparent prey, it is instead attacked by the shark.



## Green bomber worms

- Discovered off of the Oregon coast, release bioluminescent bombs when disturbed
- <http://www.youtube.com/watch?v=q4nLstCROAI>



## Shallow water polychaete glow worm



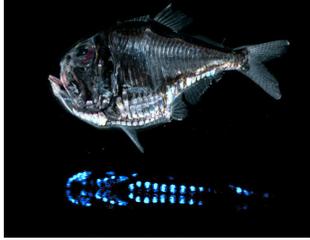
- Members of this species possess a tremendous ability to appear at the same time each night after the full moon of each month, and scientists agree that *O. enopla* uses lunar periodicity to time their emergence. Once they emerge, the males and females engage in an elaborate courtship after which the gametes are released.



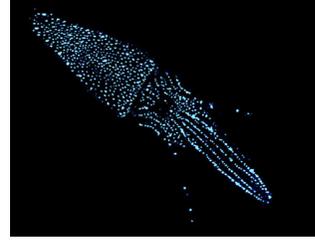
- anglerfish uses a luminescent lure packed with glowing bacteria

## counterillumination

- the silhouette of an animal against the sunlight filtering down is an easy target.
- hatchetfish is prey to bigger fish swimming below it.
- narrow silhouette and silver sides make it harder to see, but it also emits light from its belly that is a perfect match in color and intensity to sunlight filtering down

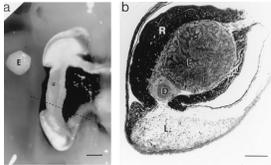


## Counterillumination



## Hawaiian bobtail squid

- Houses bioluminescent *Vibrio* bacteria in a "crypt". Uses the light for counterillumination when they hunt at night
- There is a reflector and lens as part of the light organ



- <http://www.youtube.com/watch?v=eB-M4adJleY>

## *Macropinna microstoma*

- has a transparent head and the eyes rotate around inside of it.
- <http://www.youtube.com/watch?v=R M9o4VnfHJU>



## *Dolichopteryx longipes* spookfish

- two fields of view in each eye, one focusing upward with a lens and one looking sideways with a mirror, so it can hunt while keeping an eye on what is happening below

