# Answers to Visitor Questions

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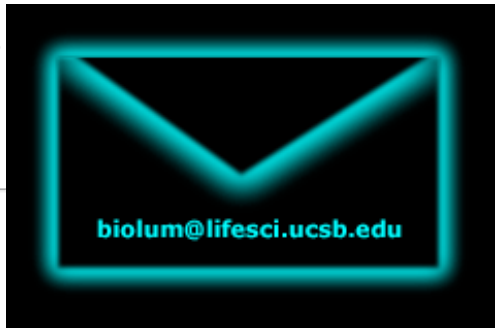
**Mailbag, Frequently Asked Questions, FAQ** -- call it what you wish. This is the place where we post replies to questions we receive. If you don't find the answer to your question below, or if you notice an error, e-mail us, and we will try to help out. Also, instead of searching the web at large, try Google Scholar for links to scientific papers.




Questions (updated 13 Mar 2008)



**I was out kayaking/swimming/scuba-diving/boating, and I saw amazing bioluminescence. Can you tell me what caused it? (and many variations...)** [ Top ]
-- C. Kleiman and others

Without a water sample I am not going to be able to answer your question with certainty, but the most likely source of bioluminescence in these situations is dinoflagellates. Other possibilities under rare conditions might be copepods (crustaceans) or a bloom of small jellyfish.

Dinoflagellates glow through an internal chemical reaction. The luciferin is structurally related to chlorophyll and is produced by the dinoflagellates themselves.

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**Is there any way to predict when the ocean will be bioluminescent? Are the dinoflagellates more numerous near shore at any particular time of year??**
**-- J. Rodgers** [ Top ]

That is a important question -- whether we can reliably predict high levels of bioluminescence. There are researchers working on this as we speak, both by monitoring dinoflagellate levels, and by analyzing their years of data.

There are definitely some seasons which have higher dino abundances. These are associated with periodic events which bring nutrients to the surface (upwelling) where they remain for a while (stratification preventing mixing with other waters). These are the same factors which can cause "normal" red tides. This effect is most pronounced times when the dinoflagellates can successfully photosynthesize (i.e. high sunshine). Add it all up, and you see why you would often get high levels in the spring time.

One researcher has found what appears to be a correlation between rainfall and red tides; the run-off brings excess nutrients into the ocean and causes events, at least on a coastal scale. So look for blooms a couple weeks after a rainstorm (this could also stir up nutrients from deeper water).

If you can predict red tides more accurately than that, then you have a valuable scientific paper on your hands!

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**How does GFP (Green Fluorescent Protein) make the luminescence of the jellyfish *Aequorea* turn green instead of blue?** [ Top ]

In short, here's how it works: Aequorin (the photoprotein) in conjunction with coelenterazine (the luciferin) produces light with a wavelength around 470 nm (bluish). The energy from this light is immediately captured by the GFP (a protein + fluor) and is reradiated as green light (504 nm). I would have to double-check the latest papers, but last I heard, it was thought to be non-radiative transfer, meaning that the energy goes directly to the GFP before a blue photon is even emitted (increasing the efficiency).

The amazing thing (well, one of them) is that this is so efficient that you can actually get more photons out from the GFP (because the longer wavelength photons have less energy than the short wavelength ones).

(The other amazing thing about GFP, and what makes it so useful, is that all the necessary components are encoded in the gene. Many other fluorescent compounds don't have the actual fluor in the gene. With GFP, you can put the gene into a creature and have full expression of a fluorescent material.)

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**What bioluminescent animals live in fresh water, and why are they so rare?** [ Top ]
-- D. Cone; also from Jean

There are probably two main answers to this question. One is the age of the environment; fresh water habitats (even something like Lake Baikal) have not been stable for as long as the oceans, so it is more difficult for an organism to evolve something over time. Secondly, there is not as much need. Visual interactions are usually more limited in fresh water (murkiness), vertical migration (a reason for counterillumination) is much less prevalent in freshwater, and the depths involved are usually much less, so sunlight is more of constant (unless the water is murky, in which case we are back to the short interaction distance). Many (but not all) of the luminous freshwater creatures are larvae of things which are terrestrial as adults.

A fuller reply to another reader:

There are only a few freshwater species which bioluminescence. Some are larvae of luminous insects, and the most often-mentioned luminous weirdo is a freshwater limpet (like a snail) called *Latia*, which is found in New Zealand. There are a also few luminous bacteria which can live in fresh water.

Speculations as to why:

1. It doesn't do them as much good.
In the ocean there are deeper depths which mean many things are living in darkness; freshwater is generally murkier and creatures uses senses besides vision to hunt [think catfish]. Other evidence for this is that there is less vertical migration (swimming up at night and down in the day) in lakes than in the ocean.

2. They haven't had as long to evolve it. (The overall diversity is greater in the ocean and things have had more room to "play")

In the end it comes down to the roles of luminescence, and many of these are poorly understood. For example, camouflage by counterillumination seems to be one of the main uses of luminescence in the ocean.

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**Why is blue a 'favored color' in marine environments while it seems absent in terrestrial organisms?** [ Top ]
-- D. Cone

This has to do with the transmission of light, and the visual sensitivities of organisms. Blue light transmits best in water, but there is not such a difference on land (where red transmits fine).

Also, (or perhaps therefore) organisms in the water may have one visual pigment, which is tuned to blue wavelengths, whereas on land, they are tuned to much longer wavelengths (possibly in addition to blue) which are predominant in the spectra of light which hits the earth.

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**To what extent is the wavelength of light emitted dependent on the chemical reaction? Or perhaps I should ask, what aspect of the chemical reaction determines the wavelength of light to be emitted?** [ Top ]
-- D. Cone

The general thought in most systems is that the luciferase (or phoroprotein) controls the color of luminescence. When you consider how many organisms use the same luciferins, especially coelenterazine, then this is almost necessarily the case. (See the chemistry pages for definitions of these terms). The luciferase can modify the spectrum (equivalent to the energy) of luminescence by affecting the environment for the oxidation luciferin. There are some nice examples in click beetles where Keith Wood and colleagues tracked down exactly what amino acids in the luciferase produce each particular wavelength.

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**Are there instances where the chemical reactions that produce bioluminescence (specificallly, the oxidation of luciferase and the addition of ATP to complete the cycle) are linked to metabolism -- the oxidation of sugars and carbohydrates?** [ Top ]
-- D. Cone

Well, not so much as you describe. Bacteria are perhaps the closest, with their requirement for oxygen and (sometimes) autoinducer -- a molecule involved in quorum sensing which accumulates to a certain level before they begin to produce light.

Another example which may be related to your question is the requirement for ATP in firefly luminescence, though this isn't really directly linked (i.e., glowing when they are eating).

Finally, there are strong antioxidant properties to luminescent reactions (i.e. they mop up oxygen radicals) so there may be light produced internally during protective reactions.

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**I was wondering if you could give me the species name and the common name of the bioluminescent fungus?** [ Top ]
-- Truthskr23, R. Ruzic, and many others

Also, from another reader:
**I live in Connecticut (also from Wisconsin, Washington, Kentucky...) and we have what is commonly refered to as candlewood. It is rotten wood which is bioluminescent. We are trying to determine if it is caused by a fungus or a beetle (or another organism). Do you know anything about it? It appears on rotting wood. It has a distinct green color. When it is disturbed it will bioluminescence.**
-- K. Tracey

Glowing wood is caused by the growth of luminous fungi. In some cases, the film covering the wood may be invisible in the light, but will appear as a dim steady glow in the dark.

There are several luminescent fungi. Some luminous genera are *Armillaria* (apparently an extremely destructive fungus for trees), *Omphalotus, Tricholomopsis,* and *Clitocybe,* all in the family Tricholomataceae, and there are certainly more...

The general common name for glowing wood, for example, is foxfire. For the particular mushrooms:
*Clitocybe* : "Poisonous Clitocybe" (creative!)
*Omphalotus* : "Jack O'Lantern"
*Armillariella* : "Honey Mushroom"

For more technical info, you might find these references interesting:

SHIMOMURA O; SATOH S; KISHI Y. STRUCTURE AND NON-ENZYMATIC LIGHT EMISSION OF 2 LUCIFERIN PRECURSORS ISOLATED FROM THE LUMINOUS MUSHROOM PANELLUS-STIPTICUS. JOURNAL OF BIOLUMINESCENCE AND CHEMILUMINESCENCE, 1993 JUL-AUG, V8 N4:201-205.

SHIMOMURA O. THE ROLE OF SUPEROXIDE DISMUTASE IN REGULATING THE LIGHT EMISSION OF LUMINESCENT FUNGI. JOURNAL OF EXPERIMENTAL BOTANY, 1992 NOV, V43 N256:1519-1525.

UYAKUL D; ISOBE M; GOTO T. LAMPTEROMYCES BIOLUMINESCENCE .3. STRUCTURE OF LAMPTEROFLAVIN, THE LIGHT EMITTER IN THE LUMINOUS MUSHROOM, L-JAPONICUS. BIOORGANIC CHEMISTRY, 1989 DEC, V17 N4:454-460.

Believe it or not, http://www.fungi.com/ is also a comprehensive source for mushrooom-related info!

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**To your knowledge, and aside from fungi, are there plants that are truly bioluminescent? Do they exist in rain forest climates? I would love to know.** [ Top ]
-- A.P. Signorelli

Also, from another reader:
**Are there any plants that exhibit such phenomena which are easily cultivated?**
-- L. Edelstein

There are not any luminous "flowering" plants which have been discovered. (That would be neat if rainforests glowed, but I think it is only likely to happen if they have something else on the vegetation in there making the light).

Fungi, some of which do luminesce, are not plants, and so they don't qualify.

The only "plants" which do make light are the dinoflagellates, single-celled marine algae, and they are not plants strictly speaking.

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**Would you have any information on the processes of inserting luminescent genomes, especially from insect to plant or**

**plant to plant?** [ Top ]
-- L. Edelstein

And also, from another reader:
**I saw a picture of a glowing plant in a book. What caused this light?**
-- Holly

Regarding gene transfer: some people have actually done what you mention (luminescence-related genes from insects into plants). This is one way that you can get a bioluminescent houseplant. The example that I know about was when some researchers put genes for firefly luciferase into a plant and then watered the plant with luciferin. They got glowing wherever the luciferase gene was expressed. However it's not that easy, and you would be quite a star if you could do that at home. In addition, you need to supply the light-emitting luciferin, which is expensive and has not been cloned.

Some scientific papers on the topic:

BARNES WM. VARIABLE PATTERNS OF EXPRESSION OF LUCIFERASE IN TRANSGENIC TOBACCO LEAVES. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA, 1990 DEC, V87 N23:9183-9187.

RIGGS CD; HUNT DC; LIN J; CHRISPEELS MJ. UTILIZATION OF LUCIFERASE FUSION GENES TO MONITOR DIFFERENTIAL REGULATION OF PHYTOHEMAGGLUTININ AND PHASEOLIN PROMOTERS IN TRANSGENIC TOBACCO. PLANT SCIENCE, 1989, V63 N1:47-57.

Lonsdale, DM; Moisan, LJ; Harvey, AJ. The effect of altered codon usage on luciferase activity in tobacco, maize and wheat. PLANT CELL REPORTS, 1998 MAR, V17 N5:396-399.

QUANDT HJ; BROER I; PUHLER A. TISSUE-SPECIFIC ACTIVITY AND LIGHT-DEPENDENT REGULATION OF A SOYBEAN RBCS PROMOTER IN TRANSGENIC TOBACCO PLANTS MONITORED WITH THE FIREFLY LUCIFERASE GENE. PLANT SCIENCE, 1992, V82 N1:59-70.

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**I am doing an assignment on the evolution of bioluminescence...unfortunately I haven't had much luck in finding any hard evidence that some species have evolved to bioluminesce in order to reproduce, protect themselves from predators, and see in the dark...** [ Top ]
-- B. Martucci

There hasn't been that much research on the specific aspects of evolution which you mention. There are some papers which might be relevant, but they are be in the scientific literature, rather than popular literature.

Besides the papers listed below, you should find some references by Jim Morin on Ostracod luminescence (Genus: Vargula). That is the most sophisticated communication system which is known for oceanic luminescence.

Hastings, J. W. 1983. Biological diversity, chemical mechanisms, and the evolutionary origins of bioluminescent systems. J. Mol. Evol. 19:309-321

Hastings, J. W. 1995. Bioluminescence: similar chemistries, but many different evolutionary origins. Photochem. Photobiol. 62:599-600

Lall, A. B., Seliger, H.H., Biggley, W.H., Lloyd, J.E. 1980. Ecology of colors of firefly bioluminescence. Science. 210:560-562

O'Kane, D. J. and D. C. Prasher. 1992. Evolutionary origins of bacterial bioluminescence. Molecular Microbiology. 6:443-449

Rees, J. F., B. DeWergifosse, O. Noiset, M. Dubuisson, B. Janssens and E. M. Thompson. 1998. The origins of marine bioluminescence: Turning oxygen defence mechanisms into deep-sea communication tools. J. Exp. Biol. 201:1211-1221

Latz, M. I. and J. F. Case. 1982. Light organ and eyestalk compensation to body tilt in the luminescent midwater shrimp, Sergestes similis. J. Exp. Biol. 98:83-104

Warner, J. A., M. I. Latz and J. F. Case. 1979. Cryptic bioluminescence in a midwater shrimp. Science. 203:1109-1110

Young, R. E. and F. M. Mencher. 1980. Bioluminescence in mesopelagic squids: Diel color change during counterillumination. Science. 208:1286-1288

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**I found a luminous earthworm in my backyard. What is it?** [ Top ]
-- Robin

Hi Robin. I am going to guess that you live in the South. Bioluminescence from earthworms is known from moist regions of the US, and 6-foot long specimens are apparently found in Australia! If you really want to get some detailed info, you might try to track down this article...

Wampler, J. E. and B. G. M. Jamieson. 1980. Earthworm bioluminescence: comparative physiology and biochemistry. Comp. Biochem. Physiol. B. 66B:43-50

A university library should have easy access to the journal (be sure to get 66B, because there is a separate 66A.)

If you have any specific questions, I could try to look them up for you. I don't have the full list of luminous species with me now, but the one from the southern US is *Diplocardia longa*. It can be up to 60 cm in length.

**More info from Milton Cormier:**
A detailed description of the earthworm system can be found in the journal Biochemistry, Vol 11, 2256-2266 (1972) R.

Bellisario, T.E. Spencer and M. J. Cormier. The bioluminescent reaction requires hydrogen peroxide, a copper-containing luciferase and a luciferin whose structure and chemical synthesis was described by Dr. John Wampler in my laboratory as N-isovaleryl-3-amino-1-propanal.

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**While we were finishing our fishing during a really high tide, we saw little green glowing lights swimming around in the water! Sometimes one, then two, then hundreds would swim around, group, and then turn off! It would appear that the "organisms" would light up and meet, then turn off. You could see a clump of them together unlit. Observing in "garage" light, the organisms appeared to be about 0.5 cm long, hair like shape. Good swimmers, moving across the bucket fairly quickly.** [ Top ]
-- W. Thoms

My usual "canned" response when people ask me what they saw glowing in the ocean is that it is probably dinoflagellates, but in your case, this doesn't work. Fortunately, you were extra smart and actually collected a bucket of the water! It's rare that I have this much information!!

Sounds like they might be polychaetes that you are seeing. These are segmented worms (annelids) which can be bioluminescent. There are famous displays of fire-worms off Bermuda, and in the tropics, but I've never heard of them off Southern California (I grew up going to the beach at Corona del Mar and Laguna.)

I'm not sure where to direct you if you want to read more, but perhaps an Invertebrate Zoology textbook would be a decent place. You could see if they look like any of the pics in there.

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**While walking down our rather secluded road at 8 p.m. this evening we saw some glowing spots of light along side the shoulder of the road. Upon capturing one of the insects we found it to be a one half inch crawling type of bug which I have never seen before. Would this be considered a "Glow Worm"? I don't recall seeing anything like these before. They seemed to glow just as a firefly does but they were on the ground. The worms were about 1/2 inch long and blended very well with the asphalt road. I would say they were gray to black in color with possibly some light colored specks of white. What are these strange creatures?** [ Top ]

At this time of year (early summer) you were probably seeing firefly larvae of one species, *Photuris*. The light organs are paired on the lower surface of the rear end of the insect. The insect can turn them on and off. These larvae will overwinter underground and emerge in the summer, either as adults or as larvae. You can often see them in damp areas near streams and ponds. If you handle them carefully, you can take them home and observe them for quite a while. Give them moist paper towelling in their bottle. Drying is their greatest risk. You can feed them bits of meat like single bits of minced gourmet cat food. In nature they feed on small invertebrates, worms, snails and the like.

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**While we were diving in Los Roques, Venezuela, we witnessed the most phenomenally high levels of bioluminescence activity. Very bright. Very active. This was during the 7th to 10th nights of the full moon.**

**Every night, the bioluminescent plankton level was extremely high. On some of the nights, the plankton formed small groups of 4, in vertical streamers. The streamers were all aligned parallel to each other. Either straight up vertically, or at a 45-degree angle to the bottom. Sometimes chains of 12-16 individuals would form.**

**There were times when all streamers would slowly get brighter. Other times they would all explode brilliantly. They would also instantaneously light up in response to someone's strobe light.**

**Do you know what that might be?** [ Top ]
-- Nancy B.

First, let me say that the luminescence you describe sounds truly incredible. I wish I could have been there to see it.

I have two suggestions as to what you were seeing. The first is the most likely:

The display consisting of four vertical spots, or diagonal lines, sounds very much like the mating display of ostracods (also spelled ostracodes) of the family Cypridinidae (genus: Vargula, also called Cypridina etc). These tiny "seed shrimp" are about the size of a mustard seed, and their body is enclosed between two clam-like valves. They are famous in the bioluminescence world for having one of the most sophisticated luminescence-based mating signals found in the ocean. At dusk, males swim up out of the reef, or the sea-grass beds, and secrete "puffs" of bioluminescent chemicals in their wake. Each pattern of flashes is species-specific, and the females, on seeing the appropriate pattern, swim up to mate with the males. It is very similar to the variations in flashing patterns exhibited by fireflies.

Jim Morin and his students have done just about all the research on these creatures, and although much of it remains unpublished, you can get a general account from:

Morin JG (1986) "Firefleas" of the sea: Luminescence signaling in marine ostracode crustaceans. Florida Entomologist 69: 105-121

Unfortunately, the issue is too old to be available from their web site, but you could probably find it at a university library. Some of this information (a figure showing three flash patterns) is also presented in: *Light and Life in the Sea*, a book by Herring PJ, Campbell AK, Whitfield M & Maddock L (eds), Cambridge Univ. Press. This might be easier to find at a library.

The other option you might consider is that it was a mating swarm of syllid polychaetes ("fireworms"). I think, though, that you would have seen these when you turned on your flashlights because they are much more noticeable than the ostracods.

Of course there could be other plankton in the water at the same time as the ostracods as well -- dinoflagellates and such -- but judging from your description, I think you were lucky enough to see one of the marvels of marine life!

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**While diving at night, I saw a large tubular organism which glowed for a long time. Someone said this was a tunicate.**

**What causes this light?** [ Top ]
-- Leslie

There have been some studies done on Pyrosomes (the only colonial pelagic tunicates which are known to be bioluminescent). They are very controversial, though. While it is generally assumed that their luminescence is bacterial, it hasn't been really rigorously demonstrated, as far as I am aware. Also, they are able to make the light turn off and on -- not typical for bacteria. This is thought to occur by controlling the microenvironment around the bacteria (pumping in more oxygen for example).

You may have already noticed this, but they are fun to stimulate using the light of a flashlight. After keeping them in the dark for a while, try shining a light on them briefly, and when you turn it off they should start to glow. There have been some experiments stimulating with different wavelengths, to see what they are most sensitive to. (See the following reference:)
BOWLBY MR; WIDDER EA; CASE JF. PATTERNS OF STIMULATED BIOLUMINESCENCE IN 2 PYROSOMES (TUNICATA, PYROSOMATIDAE) BIOLOGICAL BULLETIN, 1990 DEC, V179 N3:340-350.

One other thing to notice about pyrosomes is that they are not like other colonial tunicates: their individual "zooids" are very tiny, so a single tube-like animal is made up of hundreds of functioning units, which is different from the solitary salps. These might attain the same size, but they are a single creature (and when they form colonies or chains, the sub-units are usually more obvious).

There is a little more information in "The biology of Pelagic Tunicates," a book by Quentin Bone which may be available in a university library near you.

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**What is the genetic sequence of the ostracod/firefly/jellyfish/copepod luciferase?** [ Top ]
-- Ajay, etc.

Genes for many luciferases and photoproteins have been cloned. They can be found by searchin in Genbank. Some examples are given below. (Links open in new window):

Ostracod luciferase
Jellyfish photoprotein
Glowworm luciferase
Firefly luciferase

You might also try searching the database for Renilla, Metridia, and Pholas to see other examples.

A great resource for exploring the 3-D structures of many of these proteins is the Protein Data Bank. Try the searches there and check it out!

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**Where's the best place to scuba dive and find bioluminescent fish?** [ Top ]
-- Dave

Where do you live? If you're near the Red Sea, you can look for flashlight fish, but outside of the tropics, most of the luminous fish are from the midwater zone -- below scuba depths.

One other kind of fish you might find in the US is the midshipman fish -- *Porichthys notatus*. It is an ugly ol' thing, but it has beautiful rows of photophores along the underside. These come up quite shallow to spawn, and in certain areas you can find them tending their "nests" under rocks or shells.

Off the coast of Japan, you can find the luminous pine-cone fish (*Monocentrus*) which has luminous bacteria in it.

Plenty of non-fish things that glow in almost ANY place that you would go diving at night...

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**In the "About This Site" page of the Bioluminescence Webpage, it is written that marine bioluminescence sometimes poses a problem to the Navy. What sort of problems does the Navy encounter pertaining bioluminescence? Bioluminescence seems so harmless, so I can't imagine what challenges it creates for anyone.** [ Top ]
-- Carolyn H.

It is certainly not a problem in the sense that it is a bad thing. However it is "of interest" to the Navy. When objects move through the water they can excite bioluminescent organisms to flash. This can even reveal the presence of submarines, or our operators whose duties might require them to swim up to a hostile shore by night, risking revealing themselves to coastwatchers by the luminescence they generate.

For these reasons, the Navy is interested in research on why and where bioluminescence occurs.

Also, in the context of the marine organisms themselves, bioluminescence can be a matter of life or death. Many animals use the light to hunt prey, frighten away predators, or find mates. While beautiful to look at, bioluminescence can still be serious business.

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**I was told that were only three (3) Bioluminescent Bays in the world, one in Vieques-Puerto Rico, another in La Parguera-Puerto Rico. Would you happen to know if this is a fact (only 3), and if so, where the 3rd one is located?** [ Top ]
-- M. Picar

I would be surprised if there are only three bioluminescent bays in the whole world, but there is at least one additional famous one besides the two that you listed. There is a Bioluminescent Bay in Jamaica.

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**What organisms live in the Phosphorescent Bay in Puerto Rico?** [ Top ]
-- Ailleen

The organisms in the phosphorescent bay in Puerto Rico are single-celled organisms, called dinoflagellates. The species of dinoflagellate that is concentrated in these bioluminescent bays is Pyrodinium bahamense. It is a microscopic organism that photosynthesizes to make its own food. It produces a bright flash of blue-green light when it is physically disturbed. Bioluminescent dinoflagellates are found all over the world in the temperate and tropical oceans, but in these special bays they are found in higher concentrations than anywhere else in the world. It is thought that their high concentrations are created by the unique flushing of these bays with narrow openings to the ocean and the fact that they are lined with mangroves that add nutrients to the water that normally limit the dinoflagellates growth.

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**Hello. I was reading at a local newspaper a new initiative to control "light pollution". One of the reasons they gave to do this was to protect our bioluminiscent sea water. Sorry, I don't understand how artificial light can affect these organisms?** [ Top ]
-- G.N., San Juan, Puerto Rico.

There is some research on this question. The organisms involved operate within circadian cycles, and artificial light can potentially disrupt these cycles and their biology. Truthfully, I think it would have more effect on the tourism than the actual organisms (in this case, dinoflagellates). They "turn on" their bioluminescence machinery only in the dark and not during the day when they are busy photosynthesizing. Under continual illumination they would not die, but would likely become less responsive. (See also our dinoflagellate organism page and the next reply below.)

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**Out of curiosity, if you were to leave the light on all the time for bioluminescent dinoflagellates (i.e. *Pyrocystis fusiformis*) would the dinoflagellates always be in a state of photosynthesis?** [ Top ]
-- Douglas

Good question. People have actually done a bunch of experiments on this.

Dinoflagellates have internal circadian rhythms (meaning they operate on an internal clock like we do). Initially some residual bioluminescence ability would remain during what would have been nighttime, but it would get less and less each "night" until finally they would be in a more-or-less continual photosynthetic phase, much like a plant.

Try this Google Scholar search to find some of the scientific literature on this.

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**While on vacation in the Florida Keys last week, I observed bioluminescence in the ocean in about three feet of water near the shore. What appeared to be a small luminous rod-shaped organism was twirling at the surface. Suddenly, from about 12 to 18 inches on either side of the "rod", two luminescent "spots" raced toward the "rod" striking it. After the two spots struck the "rod", the light seemed to burst and then dissipated. I observed this just after dusk. This continued for about twenty minutes then I saw no further activity. Any ideas what caused this?** [ Top ]
-- Bob

If the small rod-shaped organism was only 1-2 cm in length it could have been a "fireworm" (Odontosyllis sp.) known to have luminescent mating displays with a tight lunar rhythm. The displays last for 20-30 min only and usually starts 30-60 min after sunset. There are several syllid polychaete worms which have this kind of mating display (the females glow at the surface and attract the flashing males). In the Bahamas, the worms are called "palolo" worms.

Some references may be found in Bioluminescence in Action (ed. P.J.Herring)(1978) p. 217. Erdman (1965) describes this swarming off Puerto Rico (Caribbean J Science 5, 103-107), and Hori (1982) Sci. Rep. Yokosuka Cy Mus. no. 29, 1-3 describes a Japanese display. Tsuji and Hill describe (Biol. Bull. 1983, 165, 444-449) a display of *Odontosyllis phosphorea*.

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**I am trying to identify a "firefly"?? that I found. This insect has two strong lights on either side of its body near the joint between the first two segments. It was on my floor and was "flipping" itself in the air by snapping its body.** [ Top ]
-- Paul K.

This sounds like it might be a luminous click beetle, possibly of the genus *Pyrophorous*. The chemistry and genetics of their luminescence has been studied to a great extent, but they are poorly known in the US because they are found more in tropical areas (like Brazil, or as you found, Florida).

Also, from another reader:
**I live in Tampa, Florida, and I found a small insect about one half inch in length and one eighth inch wide. I discovered it at night and it appeared to have two green eyes, round and resembling large periods. The color of the eyes were green and they shone very much like the green on a traffic signal.**
-- Paul K.

If the "eyes" were midway down the body it would be a luminous click beetle, *Pyrophorous*. If true eyes - on the head - they would not really be glowing but might look like if from reflected light. If you find another one alive, turn it on its back with its feet in the air and watch. If within about a minute it suddenly leaps upwards by a sudden movement of the thorax and abdomen, it is a click beetle. The leap is made by a catch mechanism between the thorax and abdomen that clicks suddenly from one position to another and throws the insect into the air. If it does this, look on the belly side side at the junction of thorax, the part with the legs, and abdomen and you should see a third light organ glowing orange. That would definitely confirm it as a *Pyrophorous*. They are well known from Florida and - I think - around the Gulf to Mexico, where they are very common and some are quite large. Yours seems quite small. 3/4 to 1 inch is what I would have expected.

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**As far as I understand, most of the deep sea luminous organisms "light up" when they are disturbed. Does not this make**

**them more vulnerable to attack? I once read something about the angler fish, which used a luminescent fishing rod to lure its prey into its mouth.** [ Top ]
-- Dirim

You're right -- it seems like it's not a good idea to be making light, because it will attract predators. In general the roles of luminescence in many of these organisms are not completely understood!

However, it is generally believed that glowing attracts, while sudden flashes repel.

Some bioluminescence is used for counterillumination -- obliterating your shadow by replacing the light you block out.

Other theories involve revealing organisms which have eaten you (or part of you) by glowing in their gut, warning coloration indicating the ability to sting, and in some cases, glowing smoke-screens to hide your escape.

Dinoflagellates in particular have been shown to use the lights as a burglar alarm, attracting secondary predators to eat animals that are trying to eat them!

We're convinced that it must be doing them SOME good, because marine animals devote so much attention to it...

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**Female fireflies use bioluminescence to attract males. But why do firefly larvae also glow?** [ Top ]
-- Ondrej Z.

Good question! Some believe the glow serves as notice that the larvae tastes very bad and is even toxic, which it is, thus helping it to avoid predators. Animals that are poisonous and active by day are often strikingly colored for the same purpose. For more info, look up the word "aposematic" which is a term for this state of affairs.

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**My husband told me there are places you can go (although he could not remember where any of these places are located) where some sort of phosphorescence actually creates a "luminescence" in beach sand -- not just the ocean water itself. He said you could walk along the beach at night and leave glowing footprints. I would love to know where such conditions exist.** [ Top ]
-- Andrea C.

Your husband is right -- the sand will light up sometimes because tiny organisms have been washed ashore by the waves. When I have seen this phenomenon, it is mainly in your footprints, but it can also happen in a ring around where you step. I believe the footprint-glow is from the organisms (most commonly dinoflagellates, but also copepods and small jellies), which had been resting peacefully in the damp sand, getting squished. The ring of light, though, seems to happen as you compress the sand, and the disturbance stimulates them. In my experience a footprint in the sand raises the sand around it and "dries it out" a little bit.

Eventhough this isn't really happening *in* the water, the organisms originated there, so you are more likely to see it in the damp sand near the ocean's edge, or following a receding tide. It would also be enhanced when bioluminescent organisms are abundant in the ocean itself.

Enjoy the show!

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**Why do lifesavers light up when you crunch them in the dark?** [ Top ]
-- Danielle

The technical term for this kind of light is "triboluminescence". It is occurring because of the release of energy during the breaking of a chemical bond (sugar) in the candy. If you do a web search on that term you should be able to find more detailed info.

Did you know that duct tape also causes light? It is caused by the breaking of the glue bonds, and you can see it if you pull a piece off the roll in a dark room. (The light is pretty dim). Look right where the tape joins the roll, on the sticky side.

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**What is the selective advantage for dinoflagellates to have bioluminescence?** [ Top ]

The best explanations for dino bioluminescence are:

(1) the flash startles a grazer just long enough to make it skip "processing" of that individual. Esias and Curl, as well as Buskey and Swift, have done experiments with copepods which seem to indicate this may be occurring.

(2) the flashes attract second order predators to eat the grazers. (The so-called Burglar Alarm). This is supported in work by Mensinger and Case.

If you search Google Scholar under those names, you should turn up some of the original research.

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**I recently bought some fish fillets at a local market in Canberra, Australia. I gave some of the left-over raw fish to my cats and the next morning when I got up a few uneaten pieces were glowing with a pale blue-white glow. At first I did not believe it but I made sure there was no other light source to confuse me with reflections etc. One piece was even flickering.**

**I have heard of some deep-sea fish glowing but I have never heard of commercial fish flesh doing this. Is this an unusual occurrence? Could the fish have been contaminated with some chemical?** [ Top ]
-- Arthur L.

You are almost certainly seeing bacteria bioluminescence. Luminescent bacteria are extremely abundant in the sea, and one way to begin a culture is to do just what you did to feed your cat!

This phenomena of glowing meat helped lead to the original discovery of luminous bacteria several centuries ago.

I would probably advise against eating glowing meat, since it indicates that the microbes have had a good chance to multiply and reach high concentrations.

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**I have a farm in Cancun Mexico where we breed insects and herps. I am interested in breeding fireflies to develop an insect museum at an Eco-Park in the state of Quintana Roo.** [ Top ]
-- Antonio E.

I am sorry to have to tell you that fireflies currently cannot be grown through the life cycle. In the States, one can collect mature larvae in the Spring and induce them to pupate and emerge as adults. That is about it.

You might have, in addition to lampyrid fireflies, a luminous click beetle in the area near you. You might also find luminescing larvae on the ground at night. In some parts of the world fireflies congregate in large numbers and flash in synchrony. More commonly, male fireflies fly alone and signal to non-flying females. The different species have different signal patterns. Depending on what is available, you might be able to collect and supply living fireflies periodically to the exhibit, but I am afraid there is presently no way to culture them.

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**I am researching a certain clam that was used in the Second World War by Japanese soldiers as a source of light. My understanding is that the clam was dried and ground to a powder. This powder was then combined with water in a glass bowl. The glow was strong enough to read by but, also, dim enough to be overlooked by the enemy. I do not know the name of this clam nor do I know if the Japanese are still cultivating or harvesting this product. Any information would be most appreciated.** [ Top ]
-- Douglas H.

The creatures you are interested in are not clams, but ostracods (sometimes spelled ostracodes). They are only a couple millimeters long, but can make a very bright light. They are called "seed shrimp" or "clam shrimp" because their shrimp-like bodies are enclosed between two "valves" which look like tiny clam shells. So rather than molluscs, they are crustaceans. (There are luminous clams of the genus Pholas found in the U.K., but not in Japan, to my knowledge.)

In fact, I have a little bag of the actual animals which were collected by Japanese soldiers in 1944. They were given to me by the Osamu Shimomura (the father of luminescence chemistry research) who got them from the lab of E. Newton Harvey (father of modern bioluminescence research). Incredibly, they still glow after more than 60 years sitting at room temperature. Instead of putting powder in a bowl, all you have to do is crush a few of the dried little animals in a moistened palm. Apparently, there was a large harvesting effort (whereby the animals were collected in great numbers and dried on the beach), but the war ended before these particular specimens were put into use.

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**Are any bioluminescent marine organisms poisonous?** [ Top ]
-- V.Z.

Yes, but it may/may not be related. For example, jellyfish are poisonous, and many are bioluminescent, but some of the strongest stingers are not bioluminescent (Portuguese man o'war and box jellies [aka cubomedusae] for example).

There are some theories that bioluminescence acts as a warning of toxicity in jellies, too ("steer clear! i'm fragile, but I sting!"). Firefly light is thought to potentially serve as "aposematic" warning coloration. Finally, red-tide dinoflagellates may be toxic as well as bioluminescent, though not always.

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**As an environmental health officer, I occasionally recieve complaints about prawns and shrimps 'glowing in the dark'. I would have thought that cooking (i.e. boiling) of the shellfish would have killed the bacteria responsible and any processed shellfish would not, therefore, carry on glowing?** [ Top ]
-- A. Dixon

Interesting question! I am not a food scientist, so nobody should make health-related decisions based on the speculations below! Of the two processes which may be involved, one seems benign, and the other possibly not...

Certain shrimp will be luminous on their own -- i.e., they have photophores (special light producing organs) usually along the under-surface, which emit light. These organs use chemicals produced by the shrimp, and possibly obtained from their diet, depending on the species.

This luminescence is benign.

The other option is the growth of luminous bacteria on the surface of the shrimp (or fish or squid). This would probably not reach visible levels unless the shrimp had been lying around dead for a while. It is not necessarily toxic, but seems like it would indicate less-than-ideal freshness.

I would expect the luminescence in either case to be destroyed by cooking. Freezing, however will not get rid of it. The first type of luminescence (intrinsic, shrimp) would become visible upon thawing, and the second (bacterial) could come back up if the food were left out at ambient temperature for a while (giving the surviving bacteria chance to grow back up).

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**A smooth caterpillar, about three inches long and maybe half an inch wide, wandered into my house in Northern California. I have had it in a terrarium for nine days and it glows all night. What can you tell me about it?** [ Top ]
-- Sandra S.

I'd guess your "caterpillar" is actually a millipede named *Luminodesmus*, which are fairly common in hilly California forests.

It has been suggested that this is actually a sort of warning coloration, warning of distastefulness, and I think cyanide is somehow involved in the light-emitting reaction, so I wouldn't eat it or anything.

If you really want to get into it, you can try to find this reference...

Kuse, M; Kanakubo, A; Suwan, S; Koga, K; and others. 7,8-dihydropterin-6-carboxylic acid as light emitter of luminous millipede, *Luminodesmus sequoiae*.

**Follow-up from Sandra: "Turns out it's a California glowworm, *Zarhipis integripennis,* female, and she laid eggs in the terrarium. "**

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**I am a research assistant studying interior designing in Turkey. For some time I am thinking designing a lighting fixture who doesn't need neither electrical energy nor solar energy. I wonder about bioluminescent life: how does it work and is it possible to use it in interiors. Can you produce the materials synthetically. If yes, can I use this light in my house?** [ Top ]
-- N. Batirbaygil

I have been asked this question a lot. The chemicals used in bioluminescence have been synthesized, but unfortunately, they are very expensive. The organisms themselves are fairly hard to maintain. They are also much dimmer than a normal electric light.

The one possibility for biological light might be cultures of luminous bacteria. You could search for "Vibrio" and read more about how people maintain them, but it would be a very subtle glow -- hard to even read by, and the reagents involved in culturing them would cost quite a bit. It would be great for an artistic statement, but not yet practical for a real house.

Until we clone the genes for luciferin, we won't be able to do much in the way of cheap lighting...

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**We just saw Finding Nemo and it's driving me crazy....That bioluminescnent fish that was chasing the clown and blue tang.....I was sure he was a microscopic organism that lived in depths too deep for regular fish to survive.** [ Top ]
-- Mrs. Poole

You are right that the bioluminescent fish in Finding Nemo was created with some "artistic license". I downloaded a still-frame from the movie's preview, and it looks like a combination of hatchetfish and anglerfish. I can almost trace the photo which was used as an inspiration. Furthermore, the milky eyes give away the fact that they based it on a photo of a dead and preserved specimen, unfortunately. (The eyes should be black and clear, not with "cataracts" in the lenses.)

While these fish are not exactly microscopic, they are typically from 1 inch to 6 inches long, and they are usually found past 400 meters, although some of the hatchetfish and lanternfish (see the photos section) can migrate at night to within 10s of meters of the surface (mostly the lanternfish/myctophids).

Congratulations on your observation and skepticism! I'm not complaining too strenuously, though, because any exposure of bioluminescence to the public will at least get people asking questions!

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**I am looking for a world map of the oceans with recorded bio hot spots of bioluminescent plankton. Do you know if such a thing exists, if so where I can find it? Even better would be if there were maps by season.** [ Top ]
-- Nicole C.

That would be great to have a map like that, especially by season. Unfortunately we are very far from having that capability. The closest approximation you might be able to get is by looking at some "ocean color" maps which show surface phytoplankton levels. This is a very rough approximation because the correlation between bioluminescence and surface Chl is fairly tenuous, but it would be roughly in the ballpark.

To measure bioluminescence, you have to actually drive/drag/deploy an instrument into the water at night, and we don't currently have global (or even regional) coverage.

The one broad-scale observation I know about was our recent finding of a milky sea from a satellite. This is described on its own page.

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**How doe you culture luminous bacteria from seawater?** [ Top ]

Basically, you would make some agar plates using either marine broth or photobacterium broth (both available as pre-mixes from Carolina biological), or you can make them yourself using recipes at www.atcc.org

http://www.atcc.org/SearchCatalogs/MediaFormulations.cfm

Search for "luminous" and for "photobacterium".

The broth and the plates are the same except for the addition of the agar (as mentioned in the recipes).

Make some plates, and then get fresh fish/grab "guts" (literally intestines/stomachs are probably the best, but even skin would probably work). Rub the tissue on the plates and incubate in the dark. After a couple days, take the plates into a

very dark area and look for glowing colonies. They may be very dim, and you can find them more easily looking out of the corner of your eye (believe it or not, more rods there).

Pick them with a serile toothpick and put them into a tube of the liquid broth. Grow with shaking (at ambient temperatures, not 37C as you would for E.coli). If you want a pure culture, you could plate this solution back out and re-isolate, to "dilute out" other hangers-on.

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**I live in Whittier, California, and this evening I noticed something glowing in my backyard. It's not quite 1/8 inch long and resembled a tiny worm, but when I tried to scoop it onto a piece of paper it turned out to be just sort of gooey, like a tiny glow-in-the-dark booger. We just had some strong rains recently.** [ Top ]
-- Matt H.

Hmm.. interesting mystery goo you have there. The usual suspects would be larva of a phengodid (like a glow-worm). Search for "flooded" in the text of this article: http://www.pnas.org/cgi/content/full/95/3/1108 (You may not be able to get access if you are not affiliated with a university, but I think it is open. Basically they say that the larvae are rare, but are driven out of the ground during flooding).

Other options are millipedes themselves, nematode worms (they have bacterial symbionts), earthworms, and fungi (growning on moist wood = foxfire).

The phengodids are pretty fragile, and so I can imagine one basically dissolving/exploding if it got super wet, but it almost sounds like a mucus coating or fecal tube from one of the aforementioned creatures.

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**What is the mechanism behind the formation of a specific coloured luminescence in any organism ?** [ Top ]

This is a complicated question, which varies depending on the organism you are examining. At the most basic level, the color represents the energy of the reaction which produces the photons. High-energy photons are at the violet/blue end of the spectrum, and lower energy photons are yellow to red.

Some animals use fluorescent proteins to shift the wavelength from their light emitting molecules. In others, it has been shown that the luciferase protein determines the color of emission from the luciferin. In a way it provides a different environment in which the molecule is oxidized.

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**Why do animals display so many colours when only apes and man can see different colours?** [ Top ]
-- Dave

It isn't true that only apes and man can see different colors. Humans have three visual pigments used for bright-light color vision, while other organisms can have one, two or many more. Different organisms perceive the world differently. For example, bees are well known for their ultraviolet vision. One of the champions is the mantis shrimp, which has at least 10 combinations of pigments and filters which convey sensitivity to different wavelengths. So depending on the targeted eye, different colors displayed by organisms would serve different functions.

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**I have read that most bioluminescent sea animals have bioluminescent organs which emit blue colour as blue penetrates easily in the sea. Why do fireflies glow yellow in colour? Does it have any specific reason?** [ Top ]
-- D. George

As with the blue and green light described for marine luminescence, the colors of terrestrial bioluminescence have everything to do with the environmental light field and the sensitivities of the eyes in that habitat. In the ocean, shallower animals tend to be greener (longer wavelength) than deep ones, probably because the sunlight hasn't been filtered to blue yet. (See Haddock, S. H. D. & Case, J. F. (1999) Bioluminescence spectra of shallow and deep-sea gelatinous zooplankton: ctenophores, medusae and siphonophores. *Marine Biology* 133: 571-582.)

On land, the light field contains much more of the longer wavelengths (yellows to reds), so bioluminescence is tuned to maximize visibility in that environment. This maximization involves the ambient light, the background color, and the visual sensitivities of the targeted eyes. In fact, it has been shown that the color of light produced by fireflies varies depending on whether they are "early" or "late" displaying species, because the background light and foliage change in appearance as the evening begins. (See Lall, A. B., Seliger, H.H., Biggley, W.H., Lloyd, J.E. (1980) Ecology of colors of firefly bioluminescence. *Science* 210: 560-562.)

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**Luciferin is initially needed for the bioluminescence reaction. How is it synthesized within organisms. I cannot find any information on pathways leading to its biosynthesis.** [ Top ]
-- Adam R.

In the case of coelenterazine, which is widely used in the sea, there isn't much known about its synthesis. There is a study showing that jellies actually have to get it from their diet, but where does it show up originally? It has been speculated that a particular amino-acid sequence can be modified to form the molecule, but this gene has never been found. Most evidence for its novel biosynthesis has been found in crustaceans (specifically shrimp) but other than that, the actual mechanisms remain unknown.

This paper (PDF file) has some info and relevant references, especially citations #22, 17, 18, and 20.

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**Respected Sir, Can you identify what mouse or rat this guy in the picture is? I took it near my house in the night and I am living in Chennai, Tamil Nadu, South India.** [ Top ]
-- David G.