

## Everything is Illuminated:

### A Guide to Fireflies and Bioluminescence



#### Scientific Names

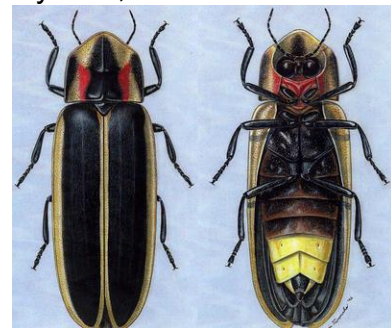
Class: Insecta  
 Order: Coleoptera  
 Family: Lampyridae

#### Common Names

firefly  
 Lightning bug  
 Glowworm (larvae)

#### What is a firefly?

Fireflies are **winged beetles!** They're not actually flies, as their name suggests. True flies, from the order Diptera, have only one pair of wings. Fireflies have two pairs of wings. Most fireflies are brown in color and have soft bodies. Their elytra (wing coverings) are more leathery than in most beetles. Fireflies are most well known for their unique ability to use bioluminescence to communicate with each other, attract mates, or attract prey. Fireflies tend to be nocturnal. There are some diurnal species, but these are not usually luminescent.



## Where do fireflies live?

Fireflies can be found all over the world. They prefer temperate and tropical climates and most commonly live in moist areas, like marshes, wet wooded areas, or near ponds and streams. Warm, humid areas such as these provide the best sources of food for firefly larvae. In the United States, fireflies are most common in the southeast near Florida and Georgia, and are rarely found west of Kansas.

## Bioluminescence

The coolest thing about fireflies is that they are bioluminescent. Bioluminescence means, “light emitted by living things.”

## How does bioluminescence work?

Fireflies produce light by a series of chemical reactions:

1. Luciferin+ Luciferase+ ATP → luciferyl adenylate- Luciferase+ pyrophosphate
2. Luciferyl adenylate- Luciferase+ O<sub>2</sub> → oxyluciferin+ Luciferase+ AMP+ **light**

These reactions are extremely energy efficient and they barely produce any heat. This is a good thing for the fireflies, because they would not be able to survive drastic increases in temperature.

## How do fireflies turn their “lights” on and off?

The mechanism by which fireflies turn their light production on and off is not well understood, but there are several theories. Some scientists think that fireflies regulate light production by controlling the amount of oxygen supplied to their photic organs. Others think that bioluminescence in fireflies is under the control of the nervous systems.

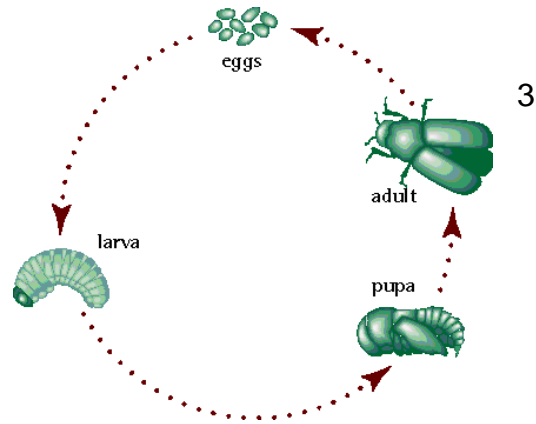
It is important that fireflies and other bioluminescent organisms are able to tightly control their light production. This **allows the light to act like a language** where different flashes act as different words. Different flashes can be produced by varying duration of the light, time between flashes, color, size of luminescent organ etc.

## Light and the Lifecycle

Light production in fireflies varies with species and with stage in lifecycle. Some species of firefly are not luminescent at all. Within luminescent species, all larvae give off light. Adults of some species produce light, while others do not.

In some species, only male adults or only female adults produce light. This might be a good point to take a look at the firefly lifecycle to understand the difference between larvae and adults.

The female firefly lays her eggs on the ground or just beneath its surface. The eggs remain there for approximately weeks, after which they hatch. The larvae continue to live on the ground where they feed and grow. When winter comes, the firefly larvae burrow underground or in the bark of trees. They emerge in the spring, feed for a few weeks, and then pupate. The pupal stage lasts for about 2 weeks. After this period of time, the fireflies emerge as adults.



### Why do fireflies light up?

Bioluminescence in fireflies is a mode of **communication**. Fireflies use their bioluminescence to communicate with different organisms about different things.



All larval fireflies are luminescent. Their luminescence is their way of communicating with predators. It acts as a **warning to potential predators**, warning them not to eat the fireflies. This warning is beneficial to both the firefly and predator because most firefly larvae contain toxins that taste bad and could be harmful if ingested.

Adult fireflies use their bioluminescence to communicate different things. Fireflies use their flashes to identify with members of the same species, and to separate themselves spatially and temporally from other species of fireflies. Adult fireflies also use flash patterns **to attract members of the opposite sex**. The flash patterns can consist of single short flashes, a long continuous flash, or patterns of many flashes in a row. The communication pattern of most of the fireflies that you will see in Ithaca (and the northeastern US) is quite specific. Males will fly around at a certain time at night and will use a particular flash pattern. The females are usually sitting on leaves or on the ground watching the males' flashing patterns. If a female is interested in a male based on his flash pattern, she will respond with a pattern of her own. The two fireflies will flash back and forth until they locate each other and mate.

Sometimes groups of fireflies will synchronize their flash patterns. This tends to happen most among tropical fireflies, although there are synchronously flashing fireflies



in the Smokey Mountains National Park. The advantage of this **synchronous flashing** is thought to be a different mechanism of attracting a mate. In this case, male fireflies begin to flash. They are attracted to each other's light. The group grows and the pattern slowly synchronizes. The huge flashing displays are able to attract large numbers of females from great distances, who then fly among the males to mate.

Some adult fireflies use flash patterns to aid in their **predation**. Females of the genus *Photuris* mimic the mating signals of other firefly species. They attract males by appearing to be a desirable mate, but when the male approaches, the *Photuris* female eats him.



### **Are fireflies endangered animals?**

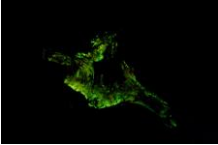
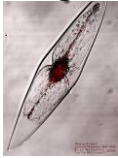


In recent years, many people have reported seeing fewer fireflies. It has been hypothesized that a combination of light pollution, habitat destruction, and industrial pollution could be causing this decline. The main culprit is probably light pollution. The light from buildings, cars etc is too bright and makes it more difficult for fireflies to detect mating signals. Fireflies that live in bright areas are less likely to mate, thus causing the decline of their species. Most of the evidence for the claim that fireflies are becoming endangered is anecdotal and not scientific. Because fireflies are so small and have short life spans of 1 -3 weeks, they are often very difficult to track and study.

### **Why is it important to study and conserve endangered species, such as the firefly?**

One word: **biodiversity**. Biodiversity is extremely important, especially in the case of an animal with a unique capability such as the firefly's bioluminescence. Not only is it important to preserve nature as a record of world history, but it is also important because different species can hold the keys to answering certain scientific problems. For example, a fluorescent protein in the jellyfish *Aequorea victoria* has become an invaluable tool in scientific research **as it can be inserted into cells blah blah**, and if the animal was extinct this would never have been able to happen. Maybe fireflies hold the key to some scientific mystery. Other benefits of biodiversity include ensuring a food supply, and increasing the ability of ecosystems to recover from disaster. But also, fireflies are simply a magical denizen of our ecosystem!

**\*\* If students are interested in helping to preserve fireflies, please direct them to the link below regarding "Firefly Watch." \*\***

**What are some other organisms that use bioluminescence in communication, and what are they trying to communicate?**

Organism	Why bioluminescence?
<p style="text-align: center;"><b>Foxfire</b></p> 	<p>A fungus that decays rotting wood and bioluminesces in order to attract other organisms (insects) to disperse its spores.</p>
<p style="text-align: center;"><b>Dinoflagellates</b></p> 	<p>Microscopic organisms that live in the ocean. Their flashes are used for predator evasion. They light up when touched. This can either startle a first predator, or alert a second predator to the presence of the first predator, which is then (hopefully) eaten.</p>
<p style="text-align: center;"><b>Jellyfish</b></p> 	<p>Same reasons as dinoflagellates.</p>
<p style="text-align: center;"><b>Shallow Water Squid</b></p> 	<p>Some types of shallow water squid bioluminesce. For them it is a form of camouflage. When seen by a predator from below at night, these squid blend in with the moon and stars above.</p>

**More Resources**

1. Branham, Marc. *The Firefly Files*. Ohio State University, 1998. Web. October 2009. <http://hymfiles.biosci.ohio-state.edu/projects/FFiles/frfact.html>

A fun website for kids with general facts about fireflies.

2. Buck, J and E. Buck. "Biology of Synchronous Flashing of Fireflies." *Nature*. 1966: 562- 564.

A scientific article about the synchronous flashing of fireflies.

3. Coder, Kim. *Foxfire: Bioluminescence in the Forest*. University of Georgia School of Forest Resources, 1999. Web. October 2009.

An article describing the bioluminescent fungus, foxfire.

4. *Firefly (Lightning Bug)*. National Geographic. Web. October 2009.  
< <http://animals.nationalgeographic.com/animals/bugs/firefly.html>>
5. *Firefly Watch*. Museum of Science. Web. November 2009.  
<https://www.mos.org/fireflywatch/>

A great site with information about the endangered status of fireflies. Also, a citizen science project in which students can track fireflies in their own backyards and help conservation scientists!!

6. Loewen, Nancy. *Living Lights: Fireflies in Your Backyard*. Minneapolis: Picture Window Books, 2004. Print.

A picture book about a firefly.