Bioluminescence

Definition:

When a living Organism produces and emits light as a result of chemical reaction is called bioluminescence.

Introduction:

- Bio means "Living" in Greek while Lumen means "light" in Latin.
- During the process, chemical energy is converted into light energy.
- The process is caused by enzyme catalyzed chemo luminescence reaction.
- All bioluminescent organisms use a reaction between an enzyme and a substrate to make light, but different species use different chemicals in the process.

Occurrence

Θ Bioluminescence on land and in freshwater is rare compared to its occurrence in the ocean

Θ In the deep ocean 90% of the animals are luminescent.

Θ Bioluminescence is found throughout the ocean-from surface to deep sea floor.

Θ Most marine animals that emit light exhibit blue green bioluminescence.

Θ Bioluminescent organism on land glow mainly in blue-green colors, but they can also glow in colors on yellow spectrum.

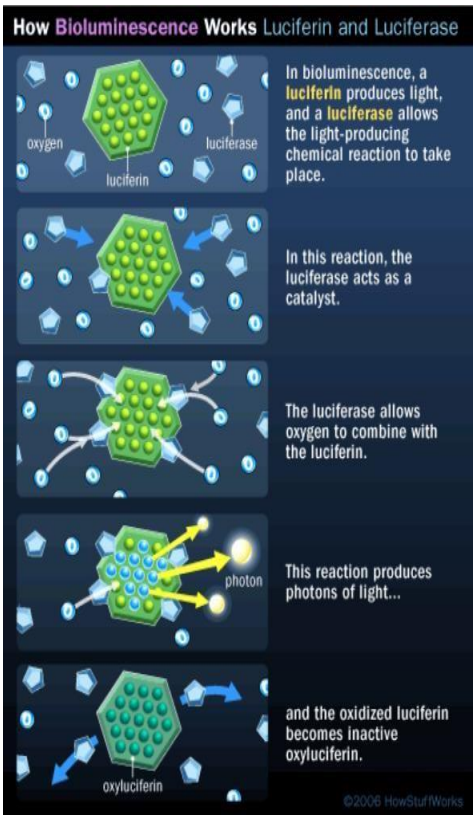
How it happens?

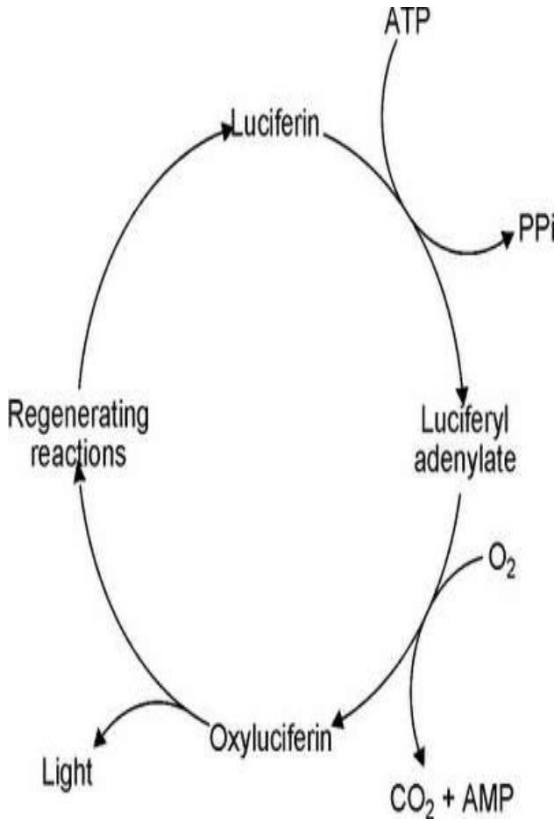
Θ Bioluminescence is product of a chemical reaction in organisms.

Θ Three ingredients are needed for bioluminescence to occur:

1. Luciferins: It is protein like light producing substance.
2. Luciferase: It is enzyme and it allows the light producing chemical reaction to take place.
3. Oxygen: It is colorless and odorless gas. Oxygen forms 20% of Earth's atmosphere and it is found in water.

Θ In the presence of Oxygen, the enzyme LUCIFERASE acts upon LUCIFERIN to produce Energy. This energy takes the form of light.





Θ The Luciferase allows oxygen to combine with Luciferin

Θ and this reaction produces light and oxidized luciferin become inactive Oxy luciferin.

Θ Some reaction do not involve this enzyme luciferase, so these reaction involve chemical called PhotoProtin that combine with oxygen and luciferase but require another agent, often an ion of element calcium, to produce light.

Role:

- Θ Bioluminescence is chemiluminescence that occurs in a living organism. In chemiluminescence, a molecule gets excited by an outside energy source, and goes to a higher energy state than its usual ground state. When the molecule loses energy, it returns to its ground energy state, and emits a photon of light.
- Θ In bioluminescence, the molecule that gets excited by an outside source is luciferin, and the outside source is the catalyst luciferase, and though all reactions contain molecular oxygen, it has different functions depending on the organism. The reaction also often involves another cofactor.
- Θ For example, in one specie of firefly, firefly luciferin, luciferase, ATP, and ionic magnesium combine to form a complex, which then gets oxidized, exciting the molecule and causing the emission of light. Fireflies typically bioluminesce in yellowish colors, which are produced by a wavelength of around 600 to 650 nanometers.
- Θ However, bioluminescence in bacteria is a little different. Bacteria-specific luciferin ($FMNH_2$) is oxidized and combines with long-chain aldehyde and is then catalyzed with luciferase.
- Θ Bioluminescent organisms are able to glow for a long period of time because the molecules involved in the reaction are rapidly losing and gaining energy, and so they are releasing many photons. Different colors are produced depending on the wavelength of the light, usually within the visible light spectrum.

Why are so many animals in the ocean are bioluminescent?

- Θ Sunlight is dim or absent ⟶ alternative way to communicate using light.
- Θ Bioluminescence plays an important role in the ecology of the ocean.
- Θ Deep ocean is completely dark environment; yet light is still important in these environment. Thus, Bioluminescence may provide a survival advantage in the darkness of deep sea, helping organism find food, assisting in reproductive process and providing defensive mechanism.

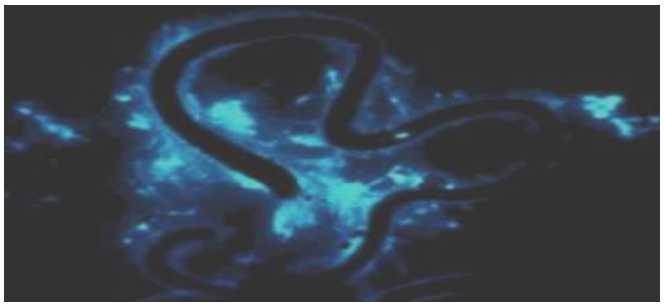
Different Bioluminescent Organisms:

1. Mushrooms and other Fungi

- Θ "Foxfire" referred to the green glow light emitted by wood decaying mushrooms and other fungi.
- Θ It was used as a light source for the early wooden submarine.
- Θ They use luciferin illudin for bioluminescence, which is toxic to ingest.

2. Worms

- Θ Both marine and terrestrial worms that exhibit bioluminescence
- Θ Earthworm luminescence is produced by the coelomic fluid, and ranges from blue to orange depending on the species.



3. Insects

- Θ Firefly is the most common terrestrial bioluminescence organism
- Θ Variety of firefly species are found in the temperate to tropical regions o the Americas and parts of S.E. Asia.

4. Lantern Fish

This lantern fish (Diaphus sp.), found in the Red Sea, has light-producing photophores along its ventral surface (belly), and a nasal light organ that acts like a headlight.

5. Jelly Fishes:

- It is estimated that about 50% of jellyfish are bioluminescent.
- Most jellyfish bioluminescence is used for defense against predators.
- Jellyfish such as comb jellies produce bright flashes to startle a predator,
- others such as siphonophores can produce a chain of light or release thousands of glowing particles into the water as a mimic of small plankton to confuse the predator .
- Some jellyfish can release their tentacles as glowing decoys.
- Others produce a glowing slime that can stick to a potential predator an make it vulnerable to its predators.

Comb Jelly Siphonophores

Uses of Bioluminescence

Θ The functions of bioluminescence are for:

1. Defence
2. Feeding
3. Communication (in the dark)
4. Mating
5. Mimicry

- ***Use of Bioluminescence in Feeding***
- The bioluminescent animal use their light to lure prey towards their mouth. e.g

Angler fish dragon fish

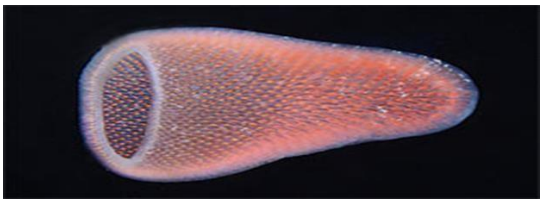
- ***Use of bioluminescence in mating***
- Fireflies use light to attract mates. Two systems are involved according to species; in one, females emit light from their abdomens to attract males; in the other, flying males emit signals to which the sometimes sedentary females respond.
- Click beetles emit an orange light from the abdomen when flying and this is sexual attractant.
- In the marine environment, use of luminescence for mate attraction is chiefly known among ostracods, small shrimplike crustaceans.
- Pheromones may be used for long-distance communication, with Use of bioluminescence used at close range
- ***Use of bioluminescence in mimicry***
- Female Photuris fireflies sometimes mimic the light pattern of another firefly, Photinus, to attract its males as prey. In this way they obtain both food and the defensive chemicals named lucibufagins, which Photuris cannot synthesize.

Photuris Photinus

Female Photuris firefly devours a male Photinus to obtain defensive compounds called lucibufagins

- ***Use of Bioluminescence in communication***

- Pyrosomes are colonial tunicates and Each zooid is only a few millimetres in size, but is contained in a common jelly-like tunic that joins all of the individuals.each zooid has a pair of luminescent organs on either side of the inlet siphon.
- When stimulated by light, these turn on and off, causing rhythmic flashing. No neural pathway runs between the zooids, but each responds to the light produced by other individuals, and even to light from other nearby colonies



- Some bioluminous bacteria infect nematodes that parasitize Lepidoptera larvae. When these caterpillars die, their luminosity may attract predators to the dead insect thus assisting in the dispersal of both bacteria and nematodes.