# Electric Organs and Bioluminescence

*Dr. R. Prasad*
*Department of Zoology,*
*Eastern Karbi Anglong College,*
*Sarihajan*

## ELECTRIC ORGANS AND ELECTRORECEPTORS

Electric organs are masses of flattened cells, called electrocytes, which are stacked in regular rows along the sides of certain fishes, e.g., the electric eel of South America. The posterior surface of each electrocyte is supplied with a motor neuron.

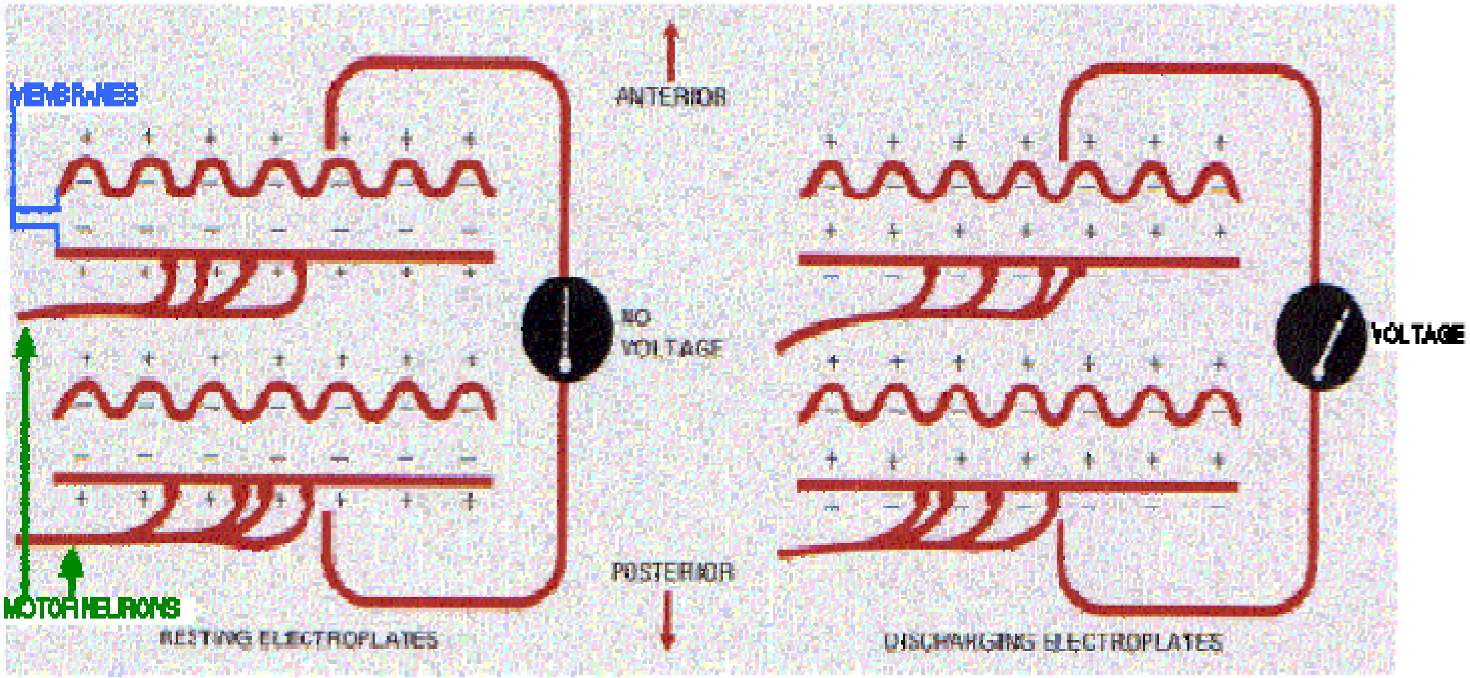


*Fig.13.7: Electric Organ of fish*

At rest, the interior of each electrocyte, like a nerve or muscle cell, is negatively charged with respect to the two exterior surfaces. The potential is about 0.08 volt, but because the charges alternate, no current flows. When a nerve impulse reaches the posterior surface, the inflow of sodium ions momentarily reverses the charge just as it does in the action potential of nerves and muscles. (In most fishes, electrocytes are, in fact, modified muscle cells.) Although the posterior surface is now negative, the anterior surface remains positive. The charges now reinforce each other and current flows just as it does through an electric battery with the cells wired in "series".

With its several thousand electrocytes, the South American electric eel (*Electrophorus electricus*) produces voltages as high as 600 volts. The flow (amperage) of the current is sufficient (0.25–0.5 ampere) to stun, if not kill, a human. The pulse of current can be repeated several hundred times each second. Powerful electric organs like those of the electric eel are used as weapons - to stun prey as well as potential predators.

**The Mechanism:** While exploring its environment, the eel emits a continuous series of low-voltage discharges. Periodically it interrupts these with a discharge of 2 or 3 high-voltage pulses. These cause nearby prey, e.g. a fish, to twitch. Within a tiny fraction of a second (20–40 ms) of detecting the twitch, the eel unleashes a volley (~400 per second) of high-voltage discharges that stun the prey enabling the eel to capture it.

Remarkably, both the twitch response and the immobilization are triggered by the prey's own motor neurons. A pair of pulses induces a brief contraction while a volley of discharges induces tetanus.

Although action potentials in the prey's motor neurons were not measured directly, two pieces of evidence support this mechanism.

1. The responses remained intact even when the brain and spinal cord of the prey were destroyed thus eliminating the possibility that the prey was relying on a sensory→cns→motor reflex.
2. Curare, which blocks the transmission of action potentials across the neuromuscular junction, did block the prey's responses.

**Electroreceptors:** Electroreceptors are also found in some nonelectric fishes and in some amphibians. Even the duckbill platypus, a mammal, has electroreceptors (located in its bill). With these it can detect the weak currents created by the muscle activity of its prey (e.g., small crustaceans) as it noses around in the muddy bottom where it feeds.

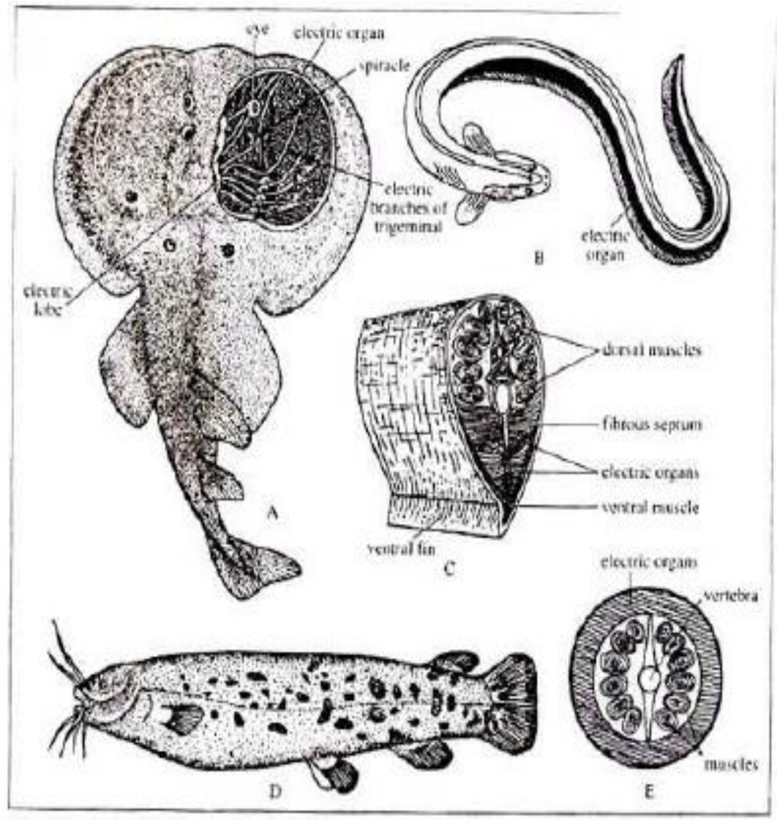


*Fig.13.8: Electric Organ of Different Fish; A. Torpedo, B. Electrophorus electricus, C. T.S. of electric organ of Electrophorus electricus, D. Malapterurus & E. . T.S. of electric organ of Malapterurus*

## Luminous Organs or Photophore of the Fishes

A number of fishes especially marine species are known to produce characteristic light through their special organs called luminous organs. These organs are commonly found in fishes living in deep-sea where the sunlight ceases to enter. The luminous organs are absent in freshwater fishes. The most important function of bioluminescence is to illuminate surroundings for the purpose of camouflage, schooling and for recognition of movement of predators in the water. The luminous organs or photophores are special gland cells of the epidermis. Their distribution on the body type and adaptive value may vary in different species of fishes.

**Structure of Luminous Organs:** On the basis of anatomy of photophores they may be categorized in two types.

**Simple Photophore:** They are small in size, about 0.1 to 0.34 mm in width. It consists of light generating cells called as photocytes. Simple type may be provided with or without mantle of pigment. The lenses are formed by grouping of cells known as lenticular cells. The distal part of photocyte is provided with acidophilic granules. A layer of melanophres surrounds the photophore. Simple type of photophores is present in sharks. In Stomias the luminous organs are logged in gelatinous corium of the epidermis.

**Compound Photophore:** This type of photophores consists of additional structures like reflectors, pigmented mantle and sub-ocular organs. The latter one is a large organ deeply embedded in dermal tissue. The photocytes are arranged in the form of cords and bands. Photogenic tissue, pigment and reflector layers are provided with nerves and blood vessels. The photogenic tissues are found in the centre of the photophore and consist of two types of glandular cells.

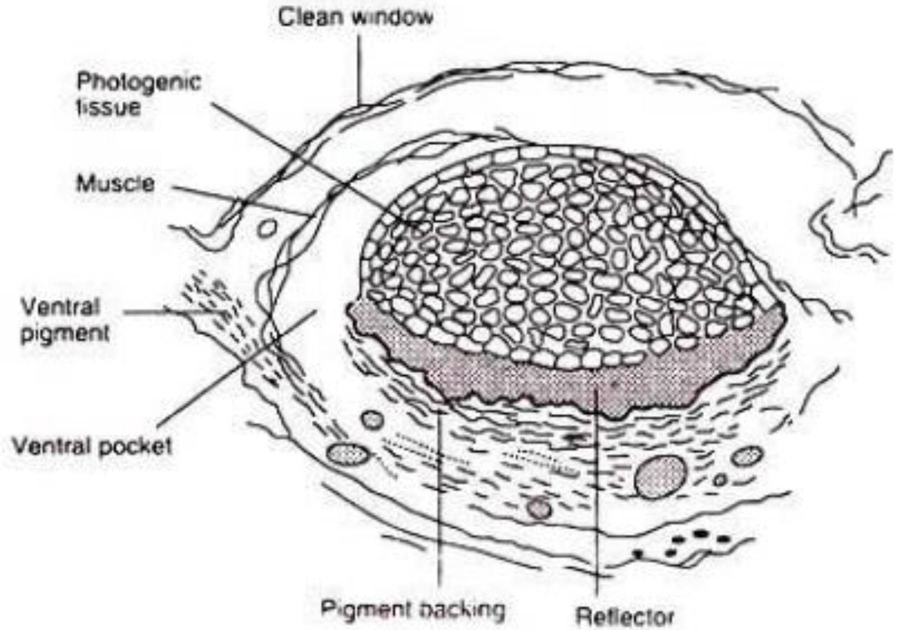


*Fig.13.4: T.S. through a sub-ocular light organ of Astronesthes richardsoni*

The mechanism of light production is peculiar in fishes and takes place the special sets of muscles present around the photocytes. When these muscles contract, they pull the outer surface of photophore downwards, causing brighter surface to be concealed. In contrast the relaxation of these muscles exposes bright surface of the photophores. In some species, movement of pigmented layer carries out concealing and rotating of photophores.

## Types of Luminous Organs

On the basis of source of illumination it may be classified as follows:

**Extra Cellular Luminescence:** Light may be generated by luminous secretion from the glandular tissues. Extra cellular luminescent organs are found in a very limited species of fishes. Certain fishes like rat tails emit light by secreting extra cellular slime. Rat tails possess special glands near its anus, which secretes slime of sufficient luminosity.

**Intracellular Luminescence:** In this type the light is produced within the glandular cell or intrinsic photocyte. These luminous organs developed from the epidermis. Fishes ornamented with this type of luminous organs belong largely to the family of teleosts, i.e., Sternoptychidae (hatchet fish), Myctophidae (lantern fish), Halosauridae (Halosaurid eel), Stomiatidae (scaly dragon fishes), Brotulidae (Brotulus), Lophiidae (anglerfish) and Zoarcidae (eel pouts).

**Bacterial Luminescence:** In this type, symbiotic bacteria present in the photophore or luminous cell discharge light. Many different species are recognized particularly the genus photo-bacterium and achromobacterium have been isolated and grown in cultures. They are common on dead fish or spoiling meat. The biochemical step in bacterial luminescence is linked to the electron transport chain of oxidative phosphorylation, in which flavin mononucleotide ($FMNH_2$) from the electron transport chain reacts with an aldehyde (RCHO) to form a complex (luciferin) that is oxidized to an acid (RCOOH) with emission of light.

$$FMNH_2 + RCHO + O_2 \xrightarrow{\text{luciferase}} FMN + RCOOH + H_2O + 0.1/hv$$

**Chemical Luminescence:** It has been established that the glandular tissue secretes a chemical substance called as luciferin, which is an indole derivative consisting of tryptamine, arginine and isoleucine. Under the influenceof the enzyme luciferase, this substance is converted into oxy-luciferin and emits blue or blue- green light. Apogon, the *Parapriacanthus* is known to possess luminous glands containing crude form of luciferin and luciferase.

**Biological Significance of Luminous Organs:** This is useful in variety of ways in marine fishes especially in deep-sea fishes.

**Illuminates Surroundings:** Some fishes utilize their luminous organs to illuminate their surroundings in the event of dimness. Thus they become able to search their prey in the dark waters. Some species (stomiatoid) are able to emit beam of light from the specially designed luminous cheek organ to catch the small creatures like planktons. The cheek organs of *Anamalops* produce light like a torch.

**As Defensive Device:** Many fishes produce sudden flash of light from their luminous organs, which helps in diverting the attention of their predators. The emission of light facilitates an escape of fish by puzzling theenemy. *Alepocephalidae* produce a glowing spark, which confuses the predator for a spur of moment, and help the fish to escape.

However, some fishes use luminous organs to enable them inconspicuous. In doing so they illuminate their ventral surface that makes them inconspicuous against lighted background above.

**As a Warning Signal:** A number of fishes use its luminous organ to warn the predators. For instance, the midshipman *Porichthys* that possesses, a toxic sign, flashes light when it is attacked by a predatory fish and avoids the danger.

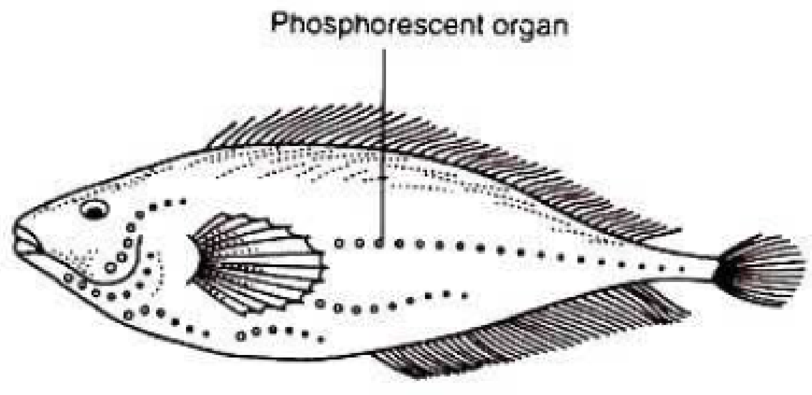


*Fig. 13.6: Light producing organs of Porychthyes*

**Recognizing Own Species:** Every species has a unique arrangement and distribution of photophores on their body, which help the fish to recognize species of same type and thus help in schooling behaviour. The luminous organs are also helpful in recognizing the mates for courtship, as the light organs may be different both in male and female. Male lantern-fish has one or many photophores present above but in the female possess it below the caudal peduncle. In some species the size of luminous organ is different in both sexes. For example in many species of melanostommiatidae, the postorbital luminous organ is larger in the male and smaller in the female.