

INSTITUTE OF SCIENCE COLLEGE, NAGPUR

Topic

'ELECTRORECEPTORS IN FISHES'

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ELECTRORECEPTORS

*Sometimes water and
electricity DO mix...*

Electroreceptors

“Specific sensory cell that mediates the perception of electric signal”.

Senses

- Own EOD
- EOD of other fishes
- Abiotic sources

Electroreceptors are abundant in the head region of electric fishes.

Electric fishes:

(Based on the voltage of EOD)

1. **Weakly electric fish** (several hundred millivolts)
2. **Strongly electric fish** (several hundred volts)

Electric fishes

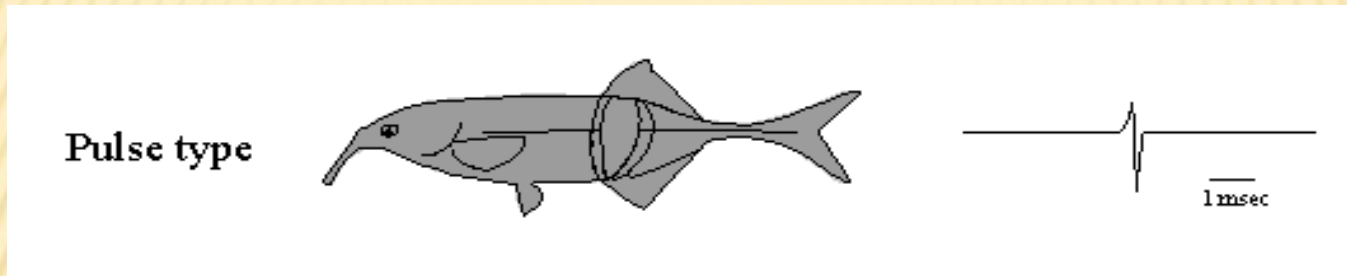
(Based on the voltage of EOD)

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graph TD; A[Electric fishes] --- B[ ]; B --- C[Pulse type]; B --- D[Wave type];
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Pulse type

Wave type

Pulse type: Brief electrical pulses followed by variable intervals of silence.



Elephant nose (*Gnathonemus petersii*)

Wave type: Sinusoidal with duration of electric pulses comparable to duration of interpulse intervals.



Knifefish (*Eigenmannia sp*)

Electric Organs

Composed of electrocytes

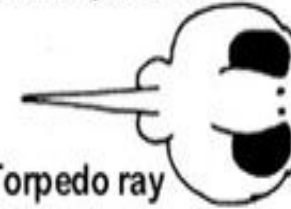
1. **Myogenic:** Derived from various types of muscles
2. **Neurogenic:** Derived from modified spinal motor axons
(order - Gymnotiformes)



Electric eel
Electrophorus



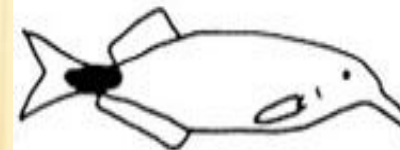
Electric catfish
Malapterurus



Torpedo ray
Torpedo



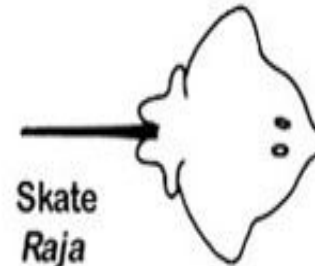
Stargazer
Astroscopus



Mormyrid
Gnathonemus



Gymnarchus



Skate
Raja



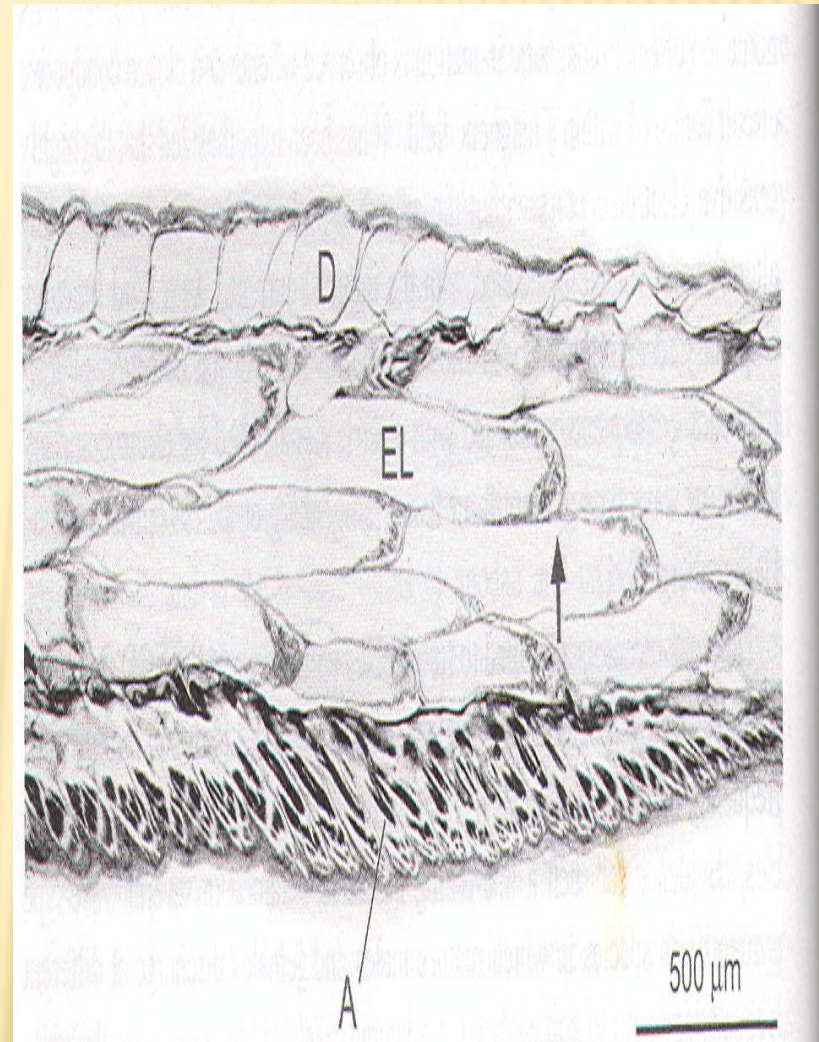
Knifefish
Gymnotus

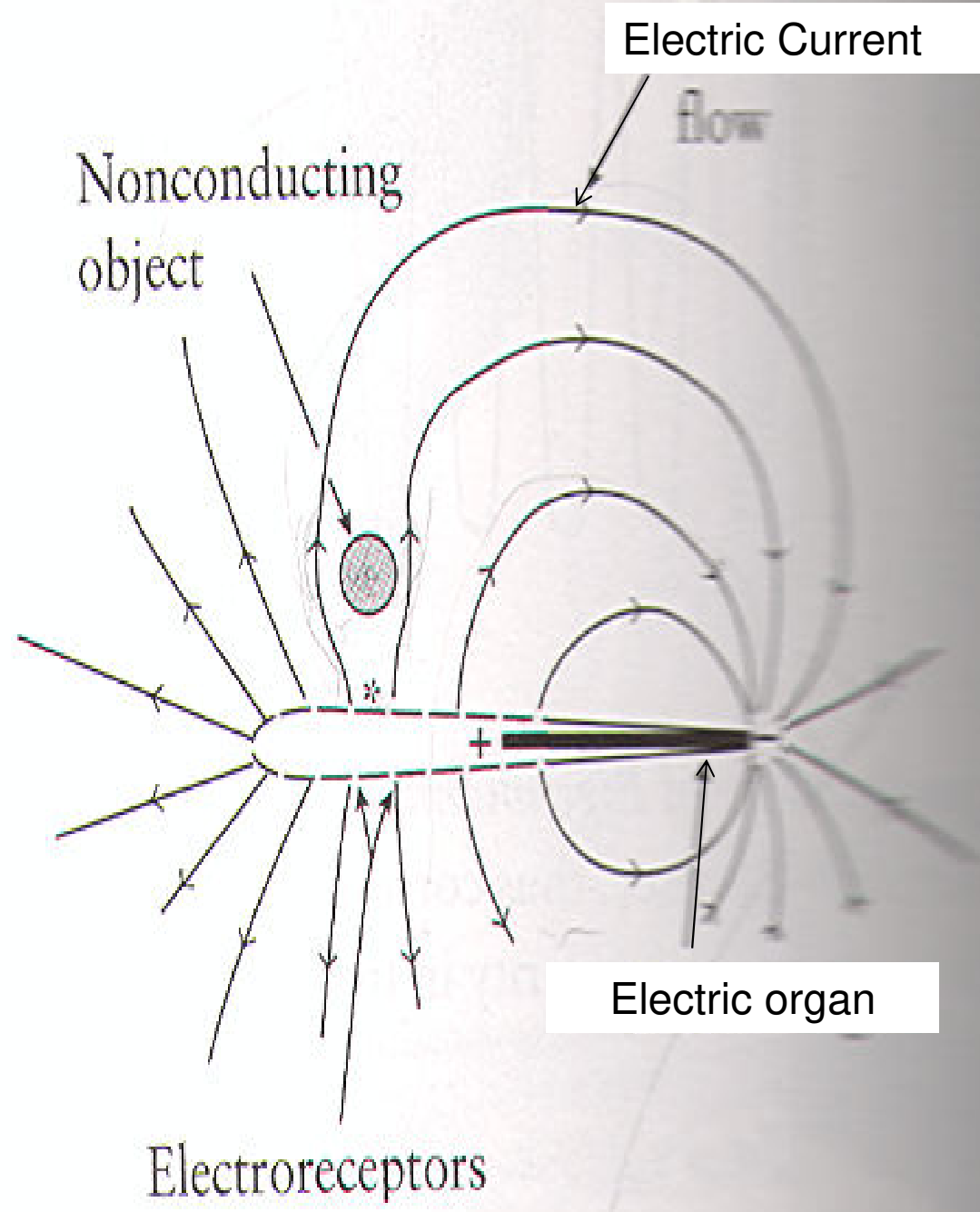


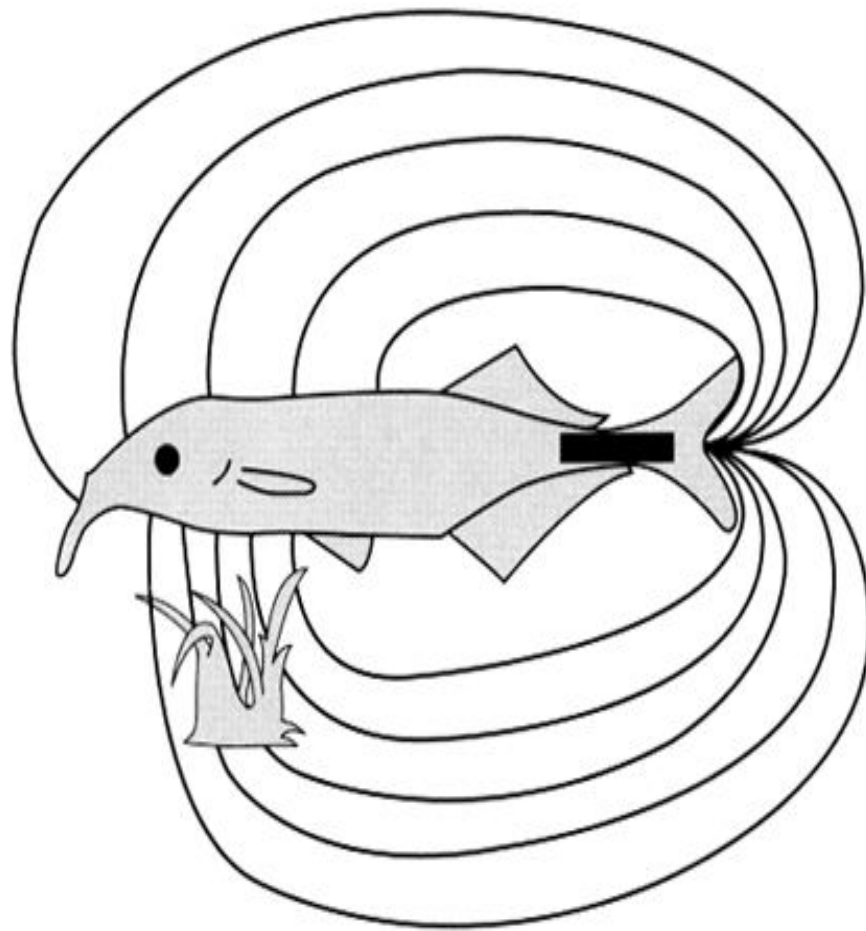
Knifefish
Sternarchus

Number of electric organs may be one or more than one.

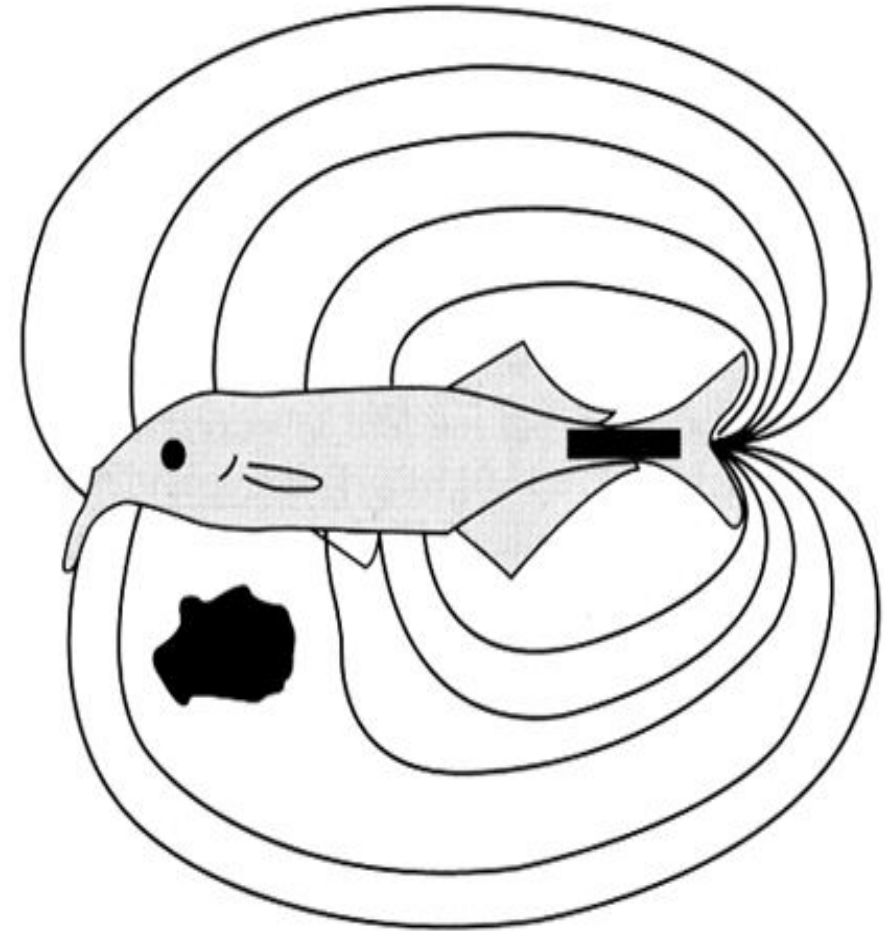
Electrocytes are arranged in series. Simultaneous firing of electrocytes results in the electric organ discharges (EODs) which are emitted in the surrounding water.







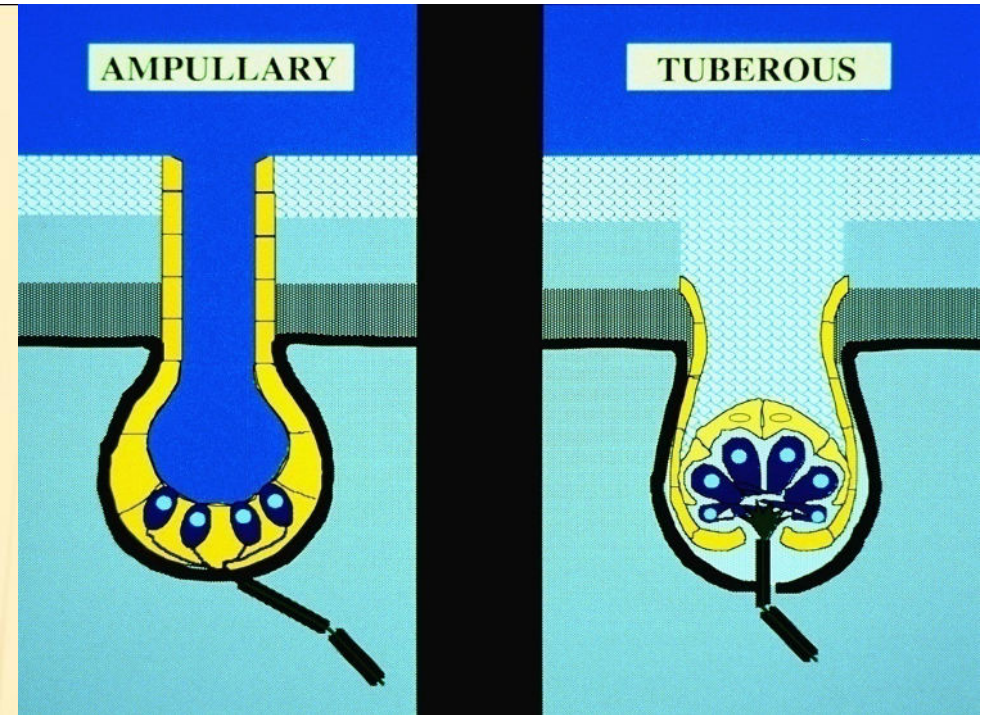
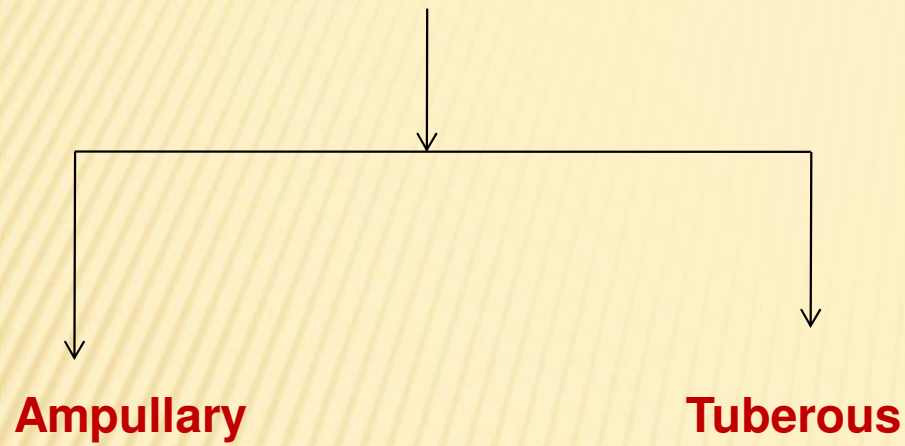
Conductor



Non-conductor

FIGURE 10.32 Electoreception. The electrical field generated by this fish is distorted by nearby objects. A good conductor, such as another living organism, draws the lines of force together. A nonconductor, such as a rock, spreads them out. Using electroreceptors distributed over its body surface, the fish senses the changes in the electrical field to “picture” its environment. (From von der Emde 1999.)

Electroreceptors



**P type
(Amplitude)**

**T type
(Phase)**

SENSORY ORGANS USED IN ELECTRORECEPTION

- **Ampullary organs** (low frequency detection)

- **Ampullae of Lorenzini** in sharks (Chondrichthyes), lungfishes (Sarcopterygii), sturgeons (Actinopterygii)
- **Pit organs** in some teleosts (catfish, knifefish, elephant fish)
- **gel-filled canal** (conductive)
- **lining of canal** with closely-spaced, flattened, high-resistance cells (no gaps - no current leakage)
- **receptor cells** at base of ampule - depolarization causes Ca^{2+} flux, causing release of neurotransmitter to sensory neuron
- **Canal varies** in length relative to the salinity of the environment
 - Saltwater elasmobranchs = long canals
 - Freshwater elasmobranchs = short canals

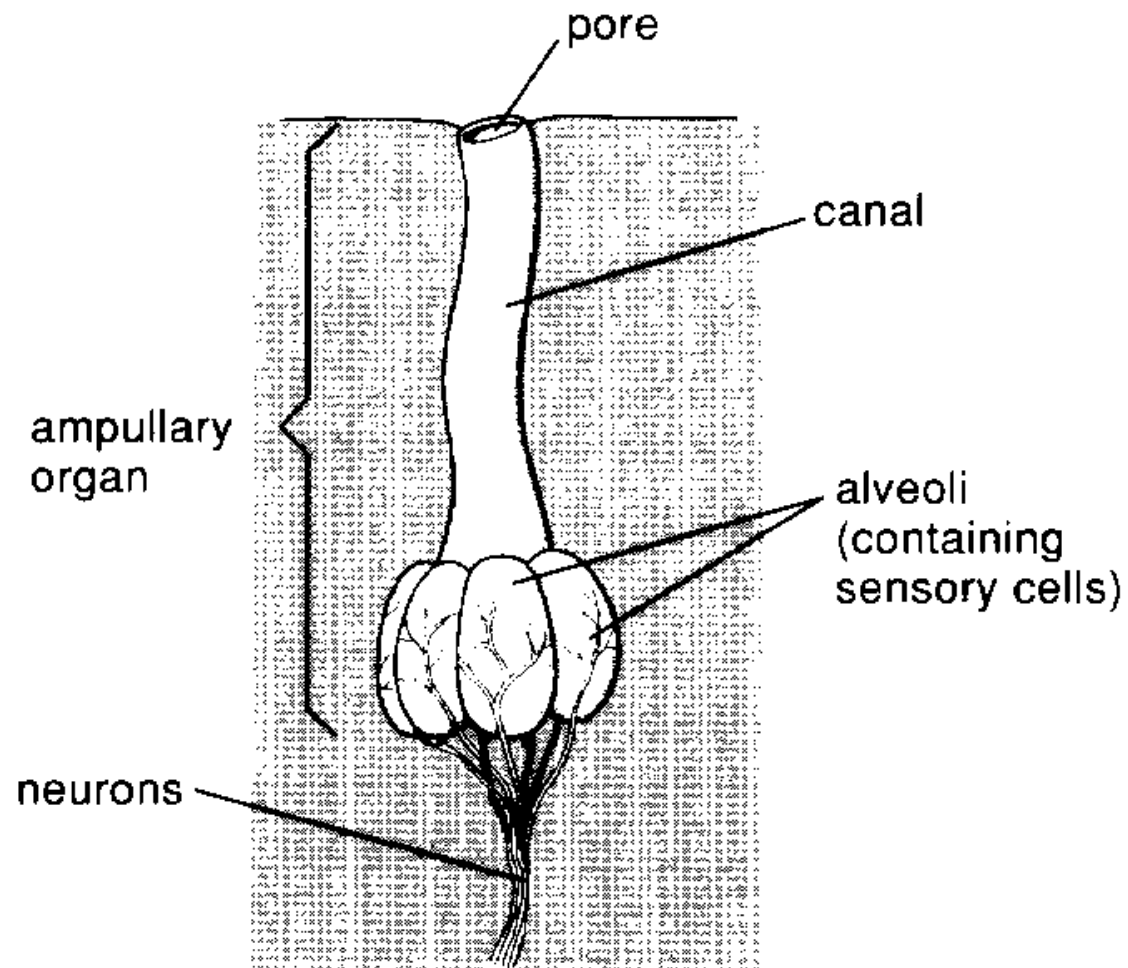
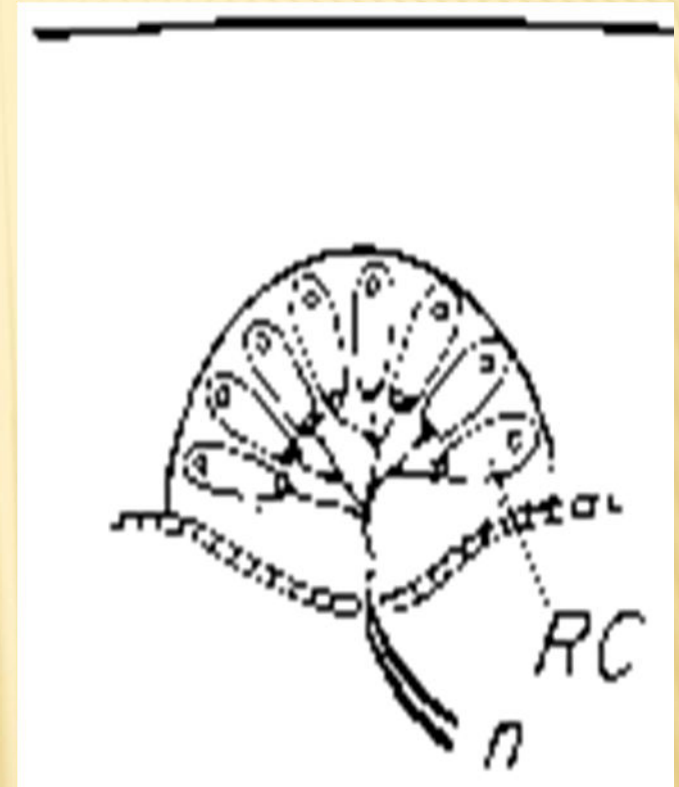


FIGURE 21-5 Diagram of ampulla of Lorenzini.

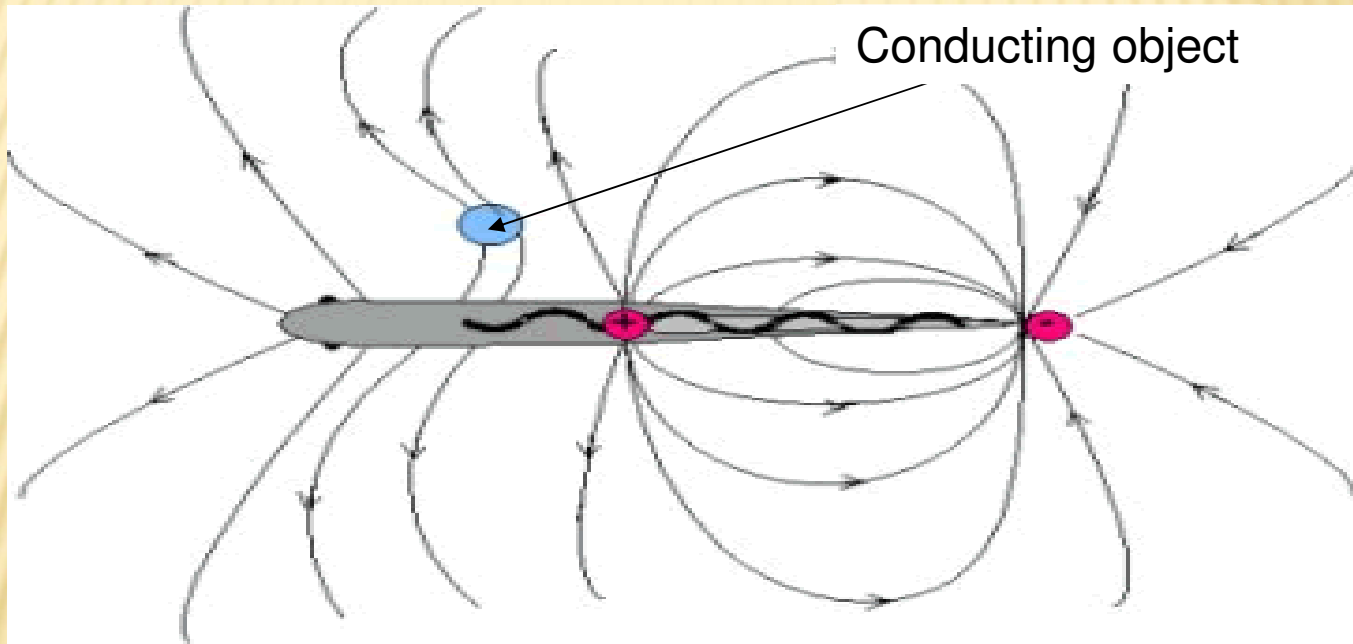
Tuberous organs

- Detect only high frequency & low voltage AC fields.
- Found in fishes that produce Electric Organ
- Discharge (EOD):
- Example :- knife fishes (Gymnotidae)
elephant fishes (Mormyridae)
- Bud-shaped swelling in epidermis
- Receptor cells constantly depolarized by self-induced EOD, causing release of neurotransmitter to sensory neuron
- Detects changes in EOD-induced field by change in the frequency of sensory impulses to brain - PHASIC receptor



Electrolocation :-

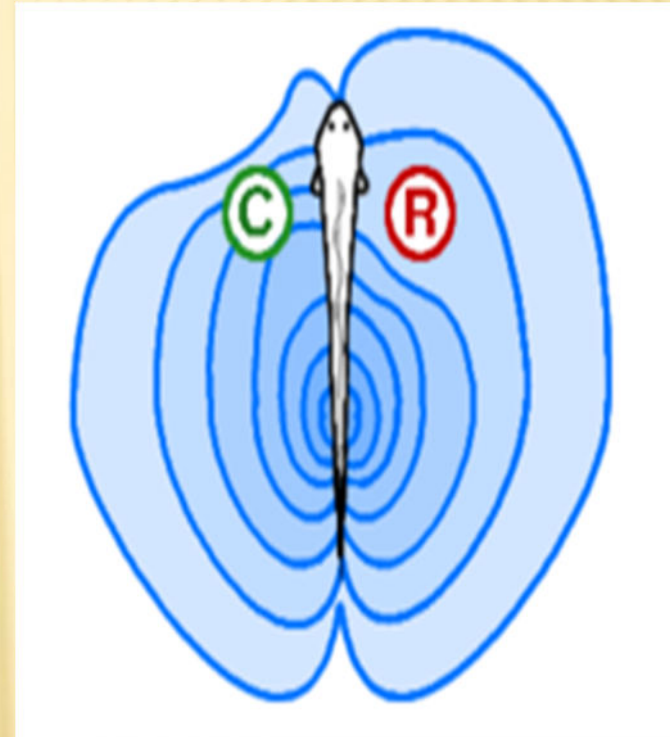
It is the ability of electric fish to detect and localize objects around them. It allows electric fish to hunt and navigate in the absence of visual cues at night or in turbid water.



An object with higher or lower conductivity than the surrounding water causes distortion of the electric field lines. This causes the area of the skin nearest to the object to have different voltage than the rest of the body, which the fish can monitor by its electro receptors. Thus, it locates the object.

ACTIVE ELECTROLOCATION

- Conductive objects concentrate the field and resistive objects spread the field.
- The animal senses its surrounding environment by generating electric fields .
- Detecting distortions in these fields using electroreceptor organs.
- Electric field is generated by means of a specialized electric organ consisting of modified muscle or nerves.
- Animals that use active electroreception include the weakly electric fish, which either generate small electrical pulses (termed "pulse-type") or produce a quasi-sinusoidal discharge from the electric organ (termed "wave-type").



PASSIVE ELECTROLOCATION

- The animal senses the weak **bioelectric fields** generated by other animals and uses it to locate them.
- electric fields are generated by all animals due to the activity of their nerves and muscles.
- A second source of electric fields in fish is the ion pumps associated with **osmoregulation** at the gill membrane.
- This field is modulated by the opening and closing of the mouth and gill slits.
- Passive electroreception is carried out solely by Ampullary electroreceptor in fish.
- It is tuned to low frequency signals (less than 1 Hz to tens of Hz).



Gymnarchus is an example of a weakly electric fish that is able to detect and locate electric fields

DIVERSITY ESTIMATES OF ELECTRORECEPTIVE FISHES AND SALIENT FEATURES OF ELECTRORECEPTIVE SYSTEMS

Electroreceptive Taxon	Common Name(s)	Spp.	Electroreceptive Mode	Electroreceptor Organs	Habitat
Elasmobranchii	Sharks, skates, rays	1,000	Passive	Ampullary	Marine
Dipnoi	Lungfishes	9	Passive	Ampullary	Fresh water
Chondrosteans	Sturgeons, paddle fishes	28	Passive	Ampullary	Fresh water
Xenomystinae	African knife fishes	2	Passive	Ampullary	Fresh water
Mormyriiformes	African electric fishes	235	Passive, Active	Ampullary, tuberous	Fresh water
Siluriformes	Catfishes	3,571	Passive	Ampullary	Fresh water
Gymnotiformes	Neotropical electric fishes	173	Passive, Active	Ampullary, tuberous	Fresh water

USES OF ELECTRORECEPTION

1. Prey detection :-

- detect electromagnetic field produced by prey..
- *extremely* sensitive: voltage gradient of 0.01 - 0.1 microvolt's/cm,
- ...or detect prey distortion of self-induced field from Electric Organ Discharge (EOD)

USES OF ELECTRORECEPTION

2. Navigation :-

- detect distortion of self-induced field from normal body functions by moving through another electromagnetic field, including Earth's
– Chondrichthyes
- Slight movement of magnetite crystal in skull against hair cells – similar to otolith function
-some Osteichthyes

USES OF ELECTRORECEPTION

3. Communication :-

- **Electrical signals are species-specific**
- **Used to signal species, sex, size, maturation state, location, distance, individual recognition, courtship, dominance, warnings, etc.**
- **Modify pulse frequency, voltage, field shape as part of the “vocabulary” for communication**
- **Examples:**
 1. **Mormyrids-elephantfish,**
 2. **Gymnotids-knifefishes,**
 3. **Siluriformes-catfish**
 4. **Rajidae-skates**
 5. **Chondrichthyes-sharks**

THANK YOU