Subject: Physiology of Coordination
(BS Zoology 6th Semester)

# Electroreception

By: Shozab Seemab Khan
(PhD Zoology Scholar)

ABAIDULLAH COLLEGE PAKPATTAN

# What is Electric Field?

- In living organisms, an electric field refers to the presence and influence of electric charges that create a force in the surrounding biological environment.
- These fields are generated by ions (charged particles like sodium, potassium, calcium, and chloride) moving across cell membranes, especially in nerve and muscle cells.
- All organisms generate electric currents, but only some produce strong, externally measurable electric discharges.

## What are Electrogenic Animals?

- Electrogenic animals are animals that can generate significant electric fields or electric discharges using specialized biological organs (electrocytes, which are modified muscle or nerve cells).
- These animals use electricity for various purposes like communication, navigation, hunting, and self-defense.

## Electric Fishes

- **Electric Eel (*Electrophorus electricus*)**
- Can generate up to 600 volts.
- Used for hunting, navigation, and defense.
- **Electric Catfish (*Malapterurus spp.*)**
- Up to 350 volts.
- Found in African rivers.
- **Electric rays (*Torpediniformes*)**
- Generate current ranging from 8 to 220 volts, depending on the species.
- Can stun prey with electric shocks.

## What is Electroreception?

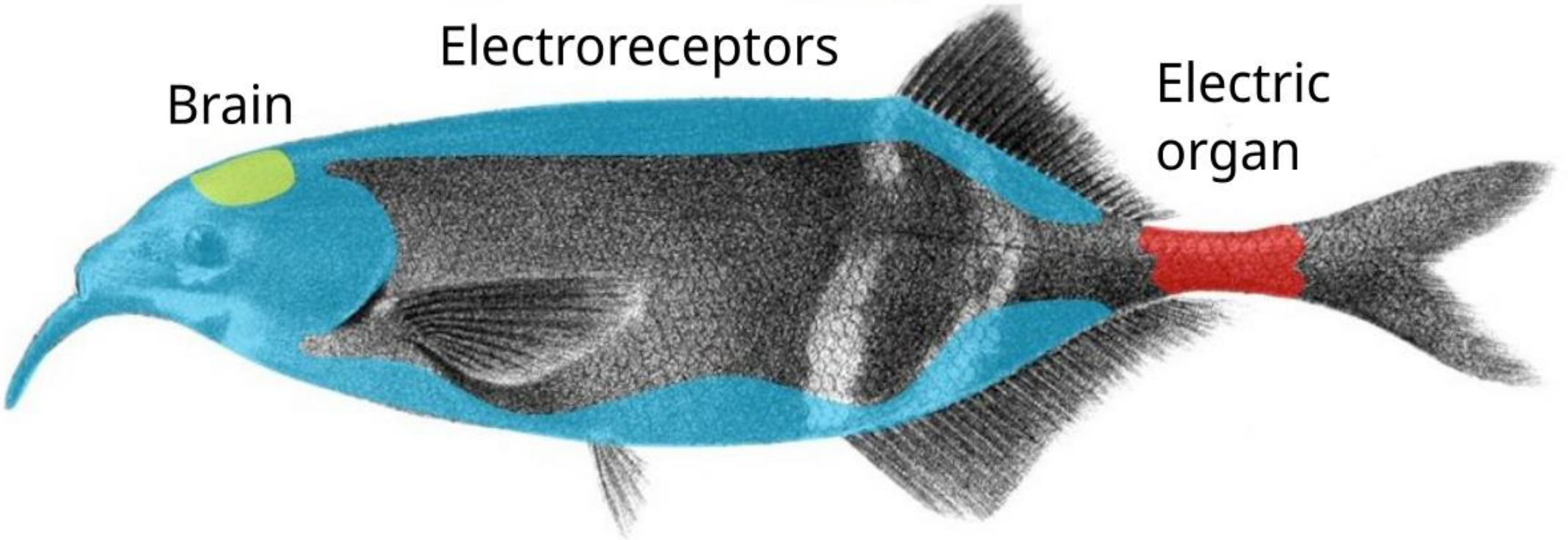
- Electroreception is the ability of certain animals to detect electric fields generated by other organisms in their environment. It plays a crucial role in navigation, prey detection, communication, and environmental sensing, especially in aquatic animals.
- The physiological mechanism behind electroreception is both complex and highly specialized.

# 1. Basics of Electroreception

- Electroreception can be passive or active:
- **Passive electroreception:**
- Detects external electric fields produced by other organisms (e.g., muscle contractions or bioelectric fields).
- **Active electroreception:**
- Involves generating an electric field and detecting distortions in it to sense the surroundings.

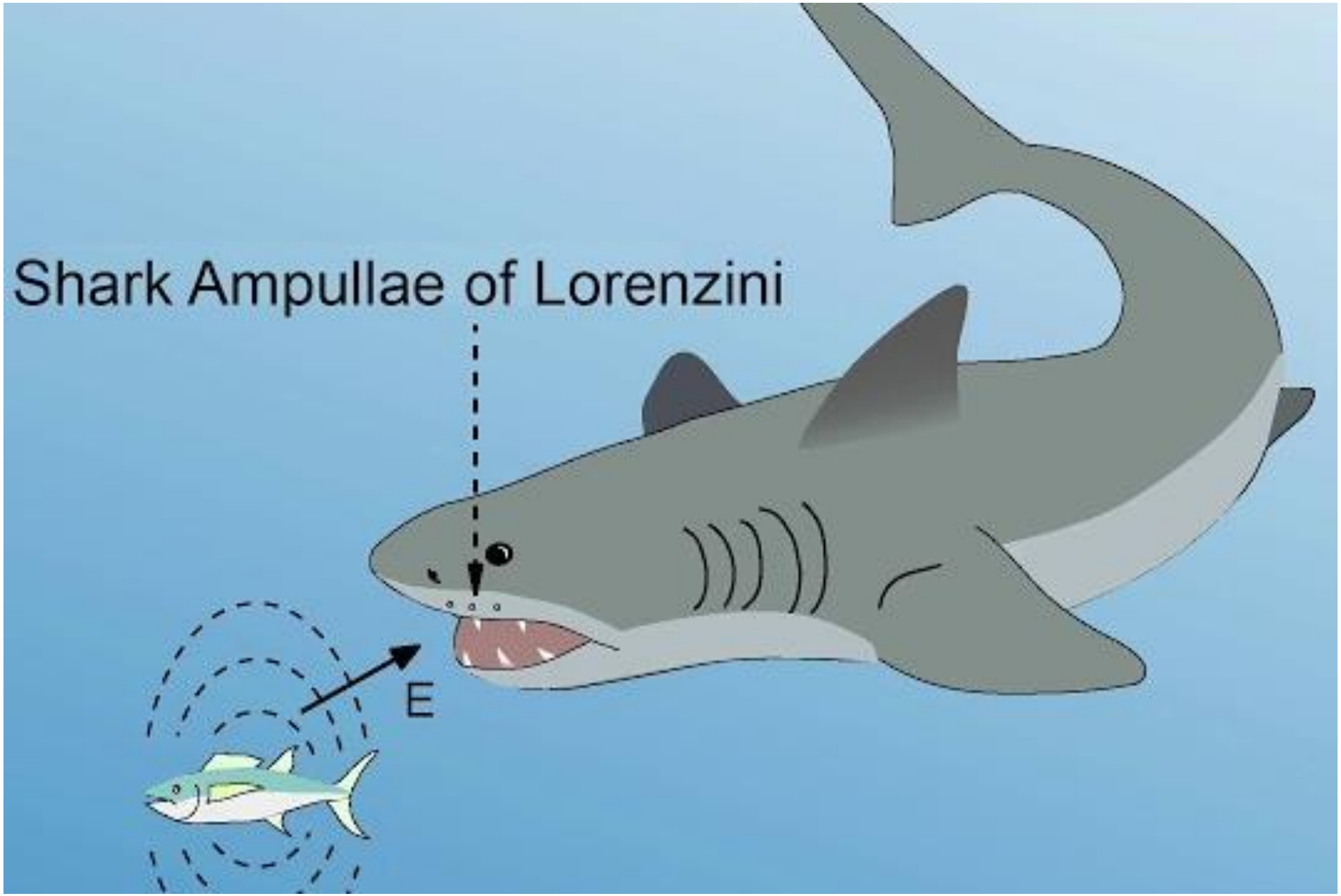
## 2. Electroreceptors

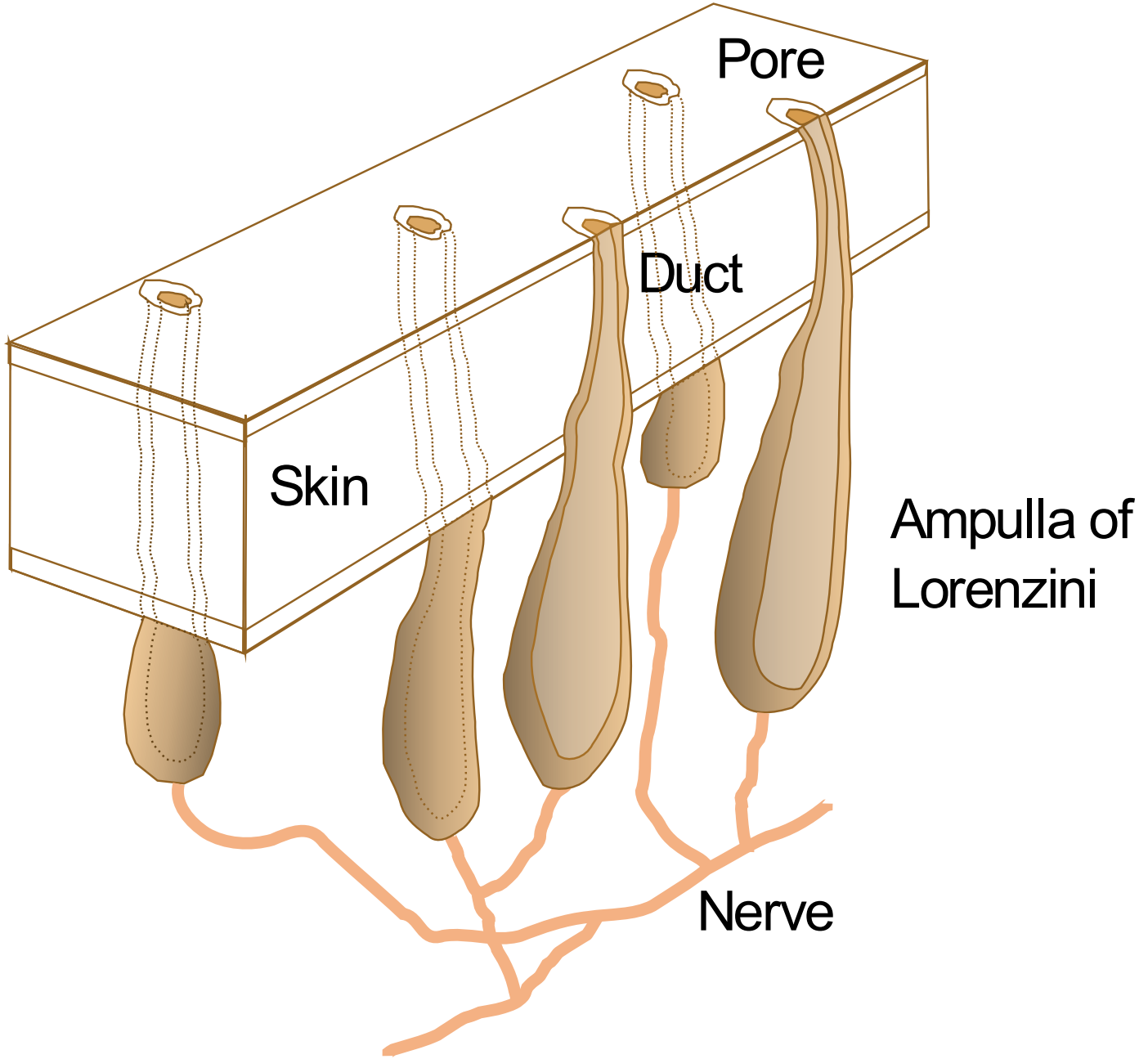
- Specialized sensory cells called electroreceptors detect electric fields. These are embedded in the skin or epidermis and are connected to the nervous system via sensory neurons.
- There are two main types:
- a. Ampullary Receptors
- b. Tuberous Receptors


Brain
Electroreceptors
Electric
organ

## a. Ampullary Receptors

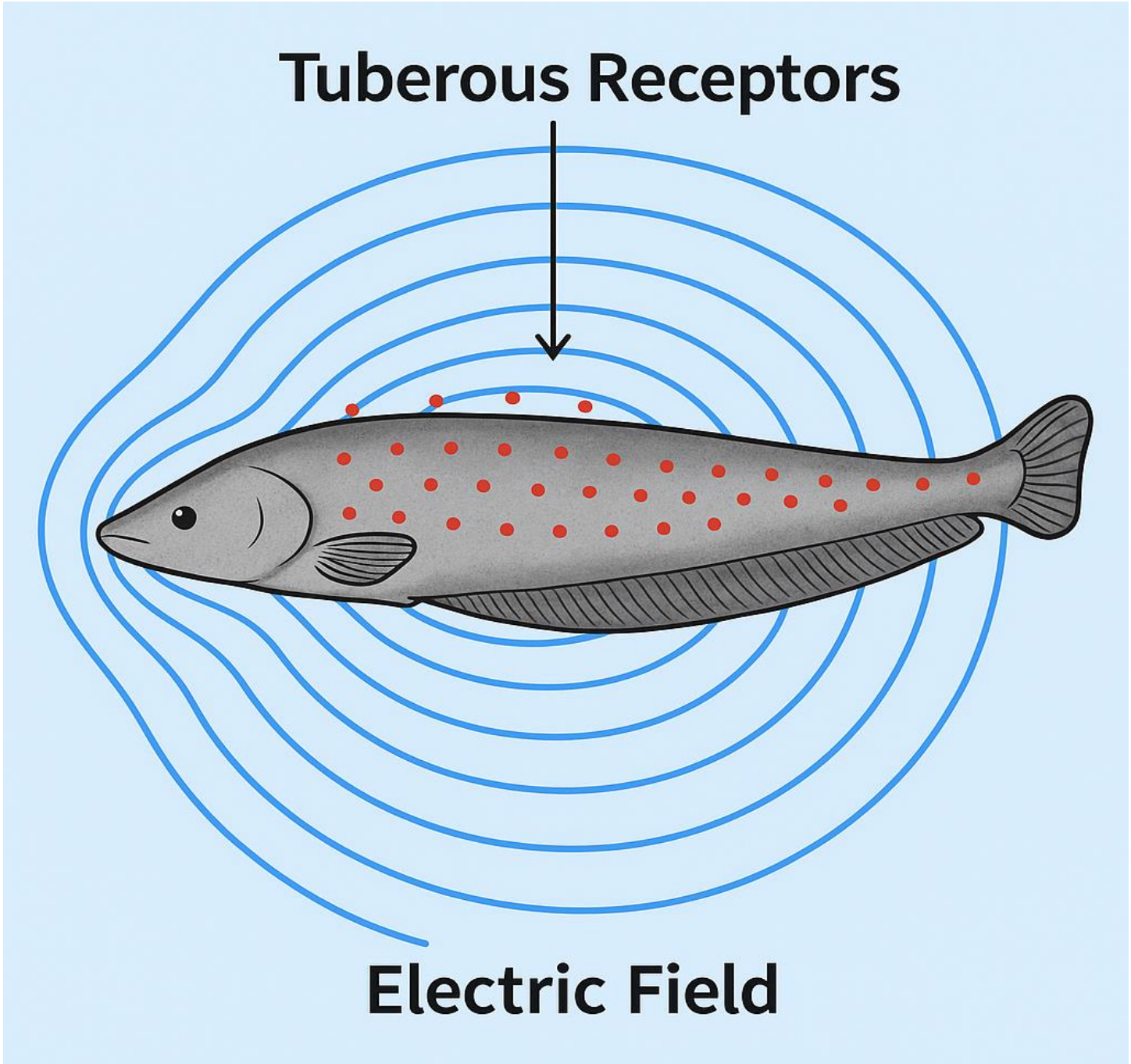
- Found in passive electroreceptors.
- Typically located in ampullae of Lorenzini in cartilaginous fish like sharks and rays.
- Sensitive to low-frequency (0.1–50 Hz) electric signals.
- **Structure:**
- Gel-filled canal leading to a receptor at the base.
- Gel acts as a conductor of electric signals from the environment.
- Receptor cells respond to voltage differences between the canal opening and internal tissue.


Shark Ampullae of Lorenzini
E


Pore
Duct
Skin
Ampulla of
Lorenzini
Nerve

## b. Tuberous Receptors

- Found in active electroreceptors.
- Found mostly in electric fish (e.g., electric knifefish, elephantnose fish).
- Detect high-frequency signals (greater than 50 Hz).
- Used in active electrolocation by sensing changes in the self-generated electric field.


Tuberous Receptors
Electric Field

## 3. Mechanism of Detection

- **a. Signal Reception**
- An external or self-generated electric field causes a voltage change across the electroreceptor membrane.
- This field can be created by:
- Muscle contractions (in prey or other animals)
- Movement of charged particles (ions) in water
- Self-produced electric discharges (in active electrolocation)

## 3. Mechanism of Detection

- **b. Transduction**
- The electric field affects voltage-gated ion channels (mainly calcium and potassium channels) in the receptor membrane.
- A change in membrane potential (receptor potential) occurs.
- If this reaches a threshold, an action potential is generated in the associated afferent neuron.

## 3. Mechanism of Detection

- **c. Neural Transmission**
- The action potentials travel along sensory nerves to the brain.
- In fish, this information is processed mainly in the hindbrain (medulla) and midbrain structures such as the electrosensory lateral line lobe (ELL) and torus semicircularis.

## 4. Active Electrolocation

- In animals with active electroreception:
- Electric organs generate a continuous or pulsed electric field.
- Distortions in the field, caused by objects with different electrical conductivity (e.g., living tissue), are detected by tuberous receptors.
- The brain maps these distortions to create a three-dimensional image of the surroundings.

## 5. Species Examples

- Sharks & Rays: Use ampullae of Lorenzini to detect prey hidden under sand.
- Electric Fish (e.g., Gymnotiformes): Use electric organs and tuberous receptors for navigation and hunting in murky water.
- Monotremes (e.g., platypus): Use electroreception in combination with mechanoreception for foraging underwater.

## Summary

- Electroreception relies on specialized receptors that detect changes in electric fields. Ampullary receptors handle low-frequency external fields, while tuberous receptors are for self-generated fields in active electrolocation.
- The process involves voltage changes triggering ion channel activity, leading to neural signals that are interpreted by the brain.

# THANK YOU