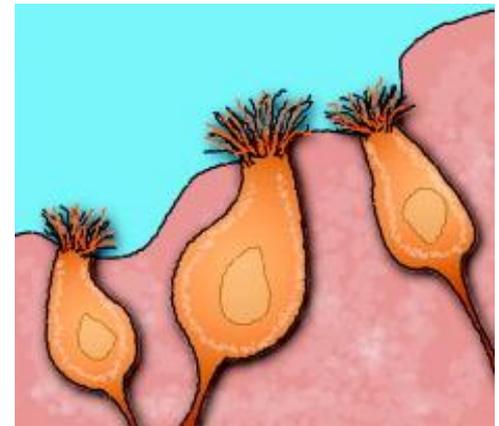
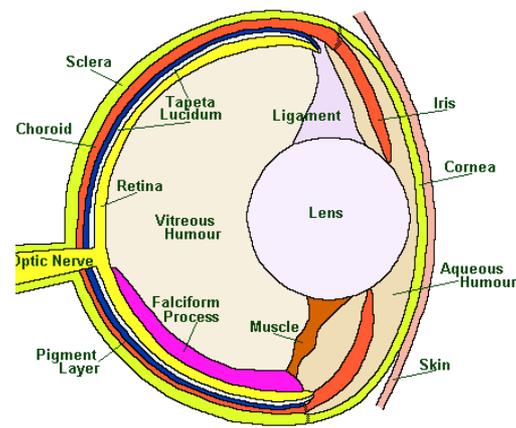
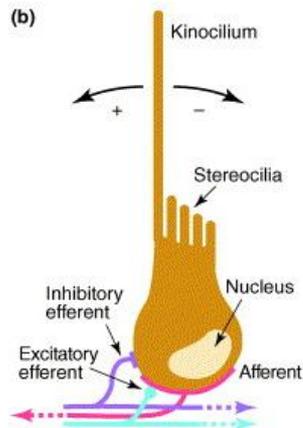
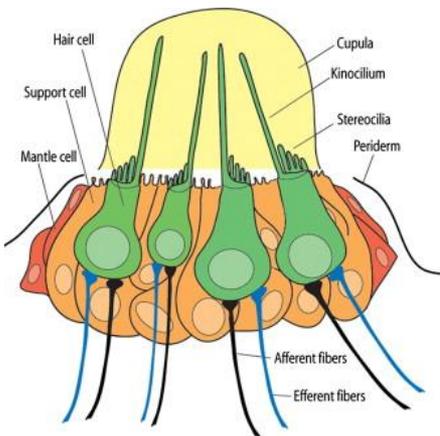


Sense Organs in Fishes



Sense organs

Specialized organs, which receive physical and chemical stimuli from the environment called sense or sensory organ.

Fishes possess a number of sense organs for smell, sight, hearing, taste, touch, temperature etc.

The sense organs are associated with the nervous system and transmit the environmental stimuli to the central nervous system.

Sense organs:

1. Eye

2. Internal Ear

3. Chemo-sensory organs

a. Gustatory (taste buds)

b. Olfactory (olfactory rosette)

4. Lateral line system

5. Electro-receptor organs

a. Ampullary organ

b. Tuberous organ

Eye

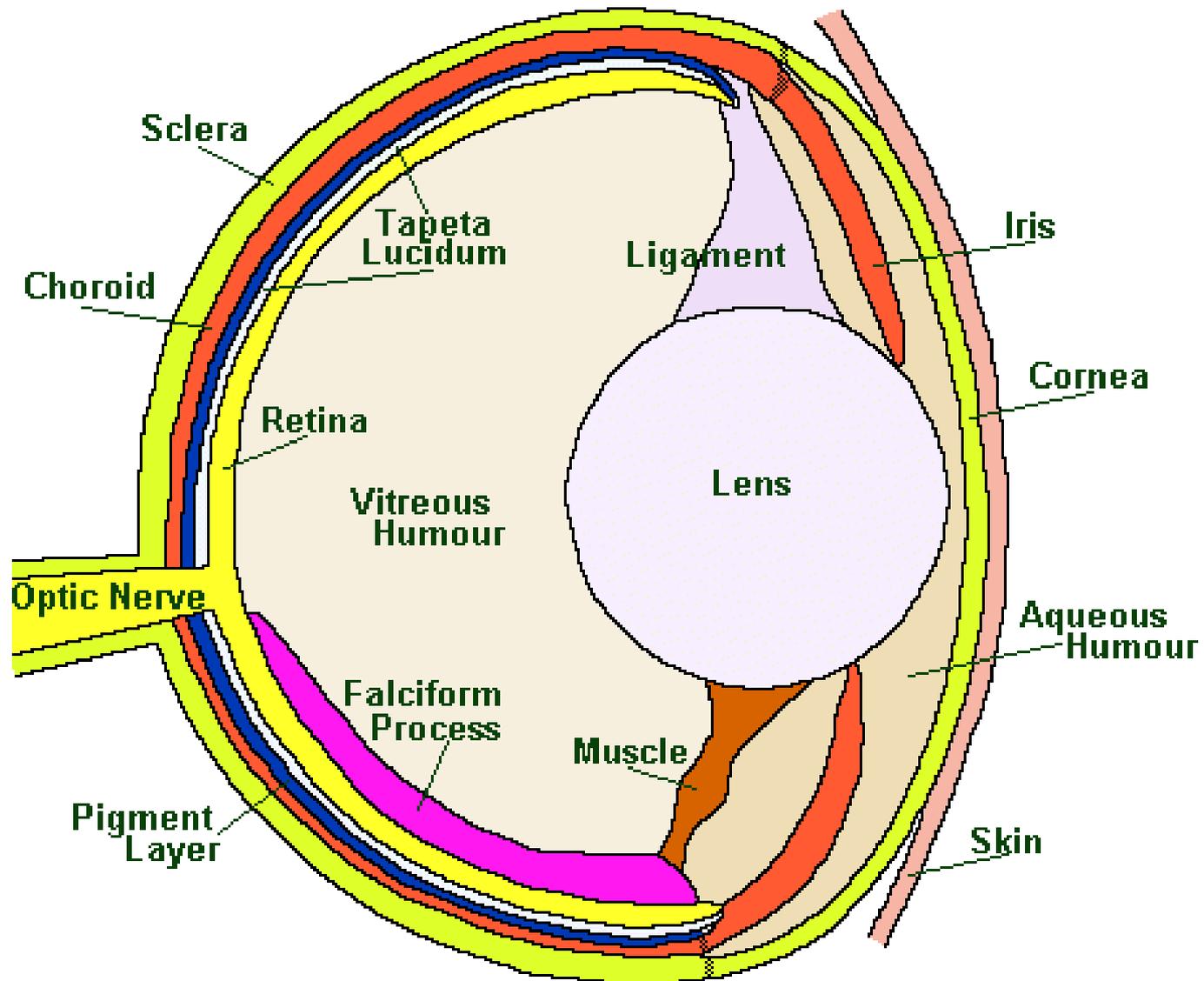
Eye are the photoreceptor organs in fishes and resembles in structure with the other vertebrate

The eye in most of fishes is lid less but some shark (Galeorhinus) possess lid like nictitating membrane. **Fishes have monocular vision. The field of view of each eye is considerably enlarged and extended forward continues laterally to almost behind the fish**

Structure:

- i) Cornea**
- ii) Iris**
- iii) Lense**
- iv) Eye ball**

A Diagrammatic Representation of a Teleost Eye



Cornea

It is the anterior part of the eye. It is composed of

corneal epithelium

corneal stroma

corneal endothelium

Most of fishes the cornea is without pigment and hence it is transparent. Cornea help in retention of water and thus prevent drying of eye

Iris

It is lies just in front of lens and composed of pupil to control the amount of light reaching to retina

Lens

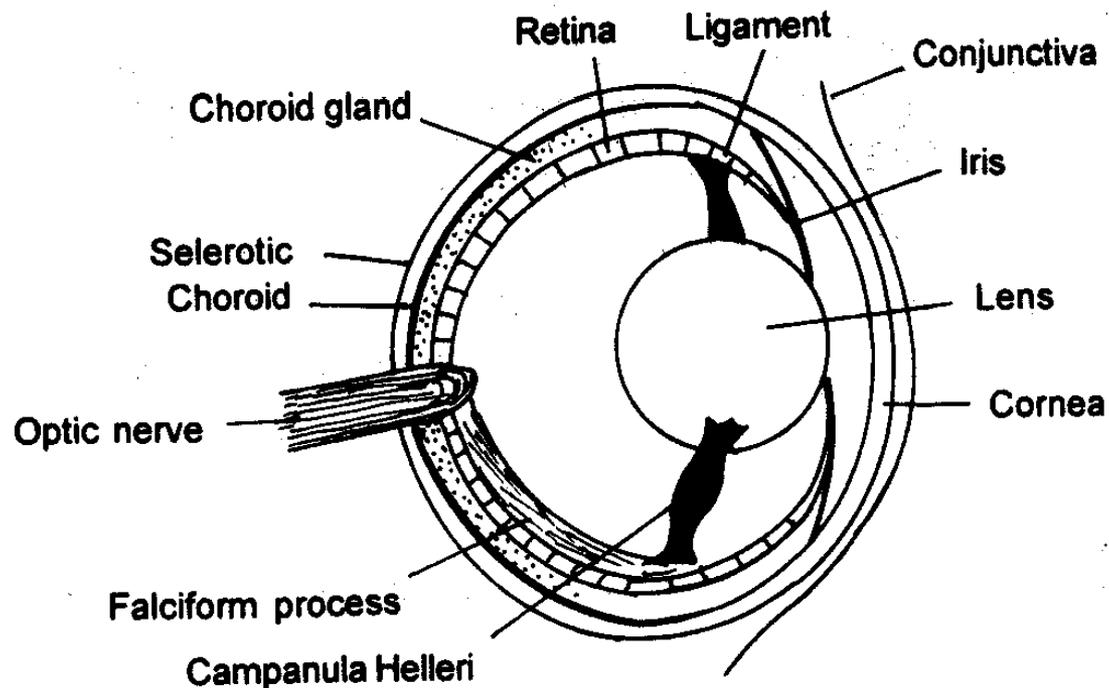
Lens is transparent, ball like and composed of non collagenous protein. Lens is covered by lens capsule and filled with lens substances.

Accommodation of lens

It is the process in which fish adjust or accommodate the lens in accordance to the viewing object.

It usually achieved by altering the position of lens rather than the shape of the lens.

Fish altering the position of the lens with the help of lentis muscle or campaluna of helleri.



Eye ball

Eye ball has usually three layers- Outer Sclerotic capsules, middle choroid and inner retina

- a) **Sclerotic capsules:** It is the outmost fibrous layer strengthened by cartilagenous element
- b) **Chroid layer:** It is the middle highly vascular layer. Horse shoe shaped choroid gland is present in the posterior end. It consists a network of blood capillaries called rete mirabile. It has counter current oxygen multiplier which supply extra amount of oxygen to the retina.
- c) **Retina:** It is the most sensitive part of the eye and closely resembles to the other vertebrates. It consists –
 - i) A layer of **light sensitive visual cells** (Rod and cone)
 - ii) a layer of **bipolar cells**, connected to the visual cells
 - iii) a layer of **ganglion cells** connecting the bipolar cells to the optic nerve.

Retina contains two types of light sensitive pigments- rhodopsin (purple colour) and porphyropsin (Rose colour)

Photo-pigment

Visual photo-pigment consists of two parts: **Retinal** (a vitamin A derivative) and **Opsin** (a glycoprotein).

Photopigments are broadly divided into two groups:

1) Purple colour rhodopsin

(opsin + aldehyde of Vitamin A) **responsible for monochrome vision**

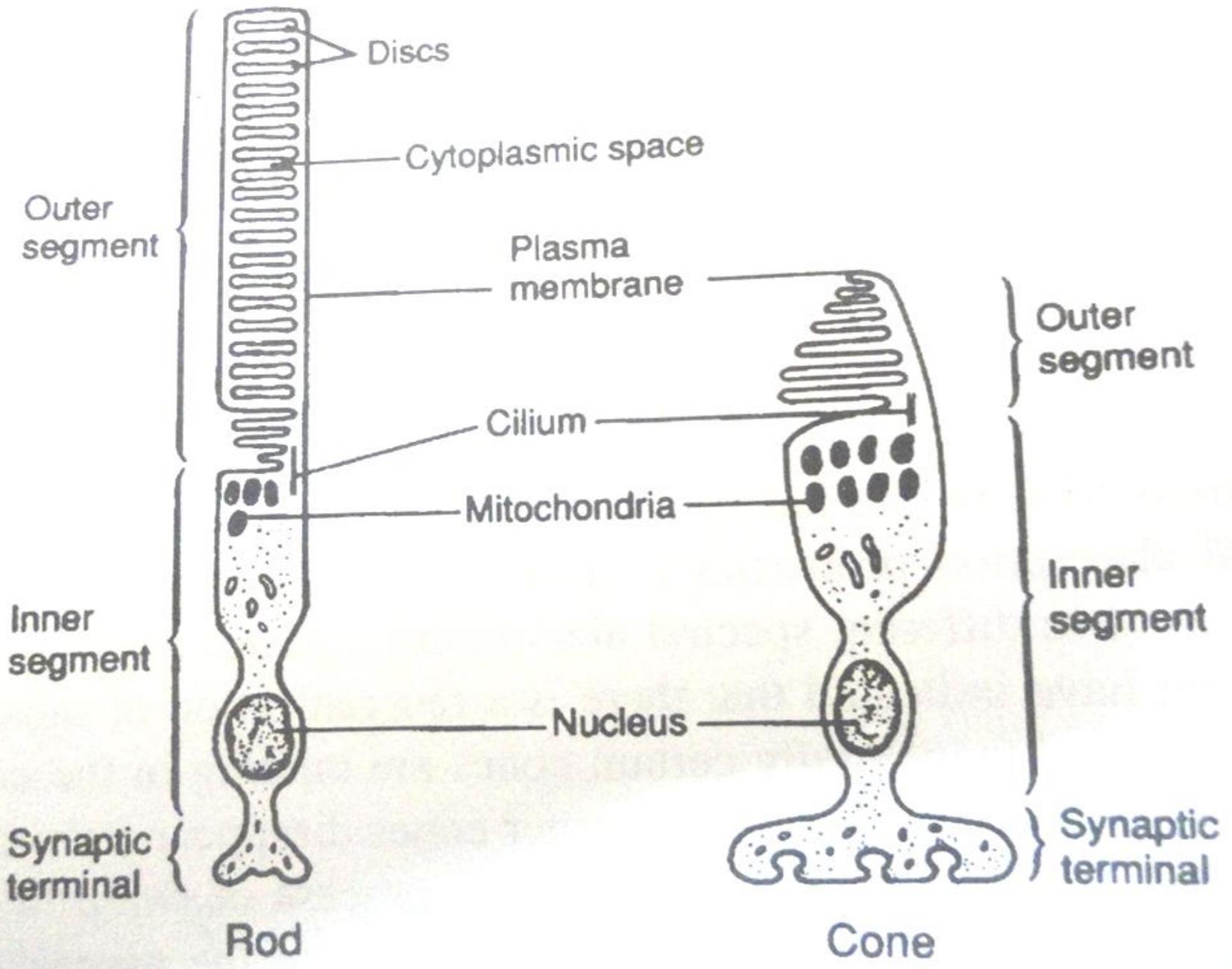
2) Rose colour Porphyropsin

(opsin + 3-dehydroretinal) **responsible for colour vision**

There are different kinds of photopigments in cones, in which opsin are same but retinal or vitamin A derivatives are slightly different in structure enabling each photopigment to absorb a different range of light wavelengths (different colors). A mixed stimulation of different cones (called red, green, and blue for their optimally absorbed wavelengths) provides for the perception of varied colors.

There is only one kind of photo-pigment in rod known as rhodopsin.

A



Difference between Rod and Cones

Rods

Photopigment: **Rhodopsin** (opsin + aldehyde of Vitamin A)

Highly sensitive, nocturnal

More photopigment, greater photon capture, high amplification

Saturation at low level of brightness

Low resolution

Slow response kinetics and long integration time

More sensitive to scattered light

Only one type of photoreceptor thus no colour vision (monochromatic)

Cones

Photopigment: **Porphyropsin** (opsin + 3-dehydroretinal)

Lower sensitivity, diurnal

Less photo-pigment, less amplification

Saturation only in intense light

High resolution

Fast response kinetics and Short integration time

More sensitive to direct rays emanating from target

Several type of photoreceptor with differential sensitivity and hence the capacity for colour vision

Dark and light adaption of fish eye

In bright light, the very light-sensitive rhodopsin in rods cannot be regenerated as fast as it is broken down, so most of the rhodopsin remains inactive. As a result, the less light-sensitive pigments in cones are active in normal or bright light.

When fish move from bright conditions to dark conditions, the photo-pigments in cones are too insensitive to detect light, vision returns as rhodopsin is regenerated, a process called dark adaptation.

When fish again move from dark to bright conditions, very light-sensitive rods are suddenly overwhelmed with stimulation, producing the sensation of glare. Light adaptation occurs as the rhodopsin in rods is completely bleached and the less light-sensitive cones resume activity.

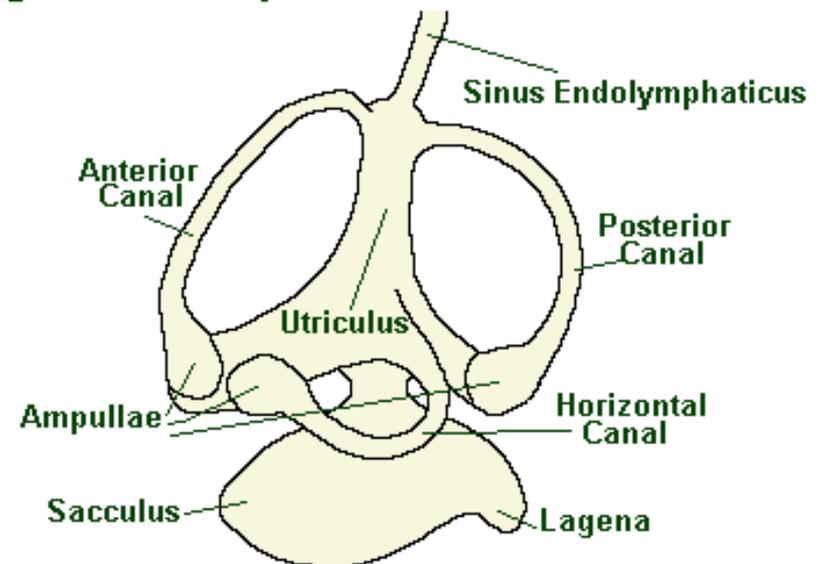
Internal Ear or Membranous Labyrinth

- The membranous labyrinth or the internal ear is the chief organ of hearing and equilibrium.
- Internal ear is a membranous sac partially divided into an upper chamber utriculus and a lower one called sacculus, having a small outgrowth, the lagena.
- Three semi circular canals open into the utriculus.
- Each canal has a small swelling at the end called ampulla.

The cavity of utriculus, sacculus and lagena contain a fluid called endolymph and group of highly sensitive cells (Sensory Hair Cells) are present in their wall.

In the cavity of ear, solid concretions called otolith are present. Three otoliths are present in three sac and called lapillus, sagitta and asteriscus.

Diagrammatic Representation of a Teleost Ear

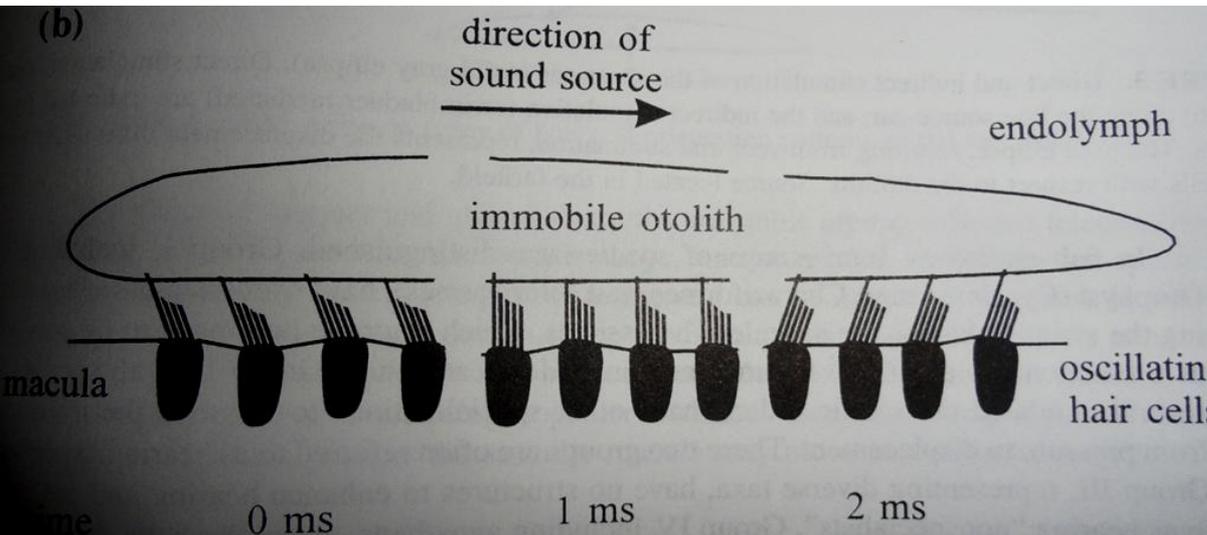
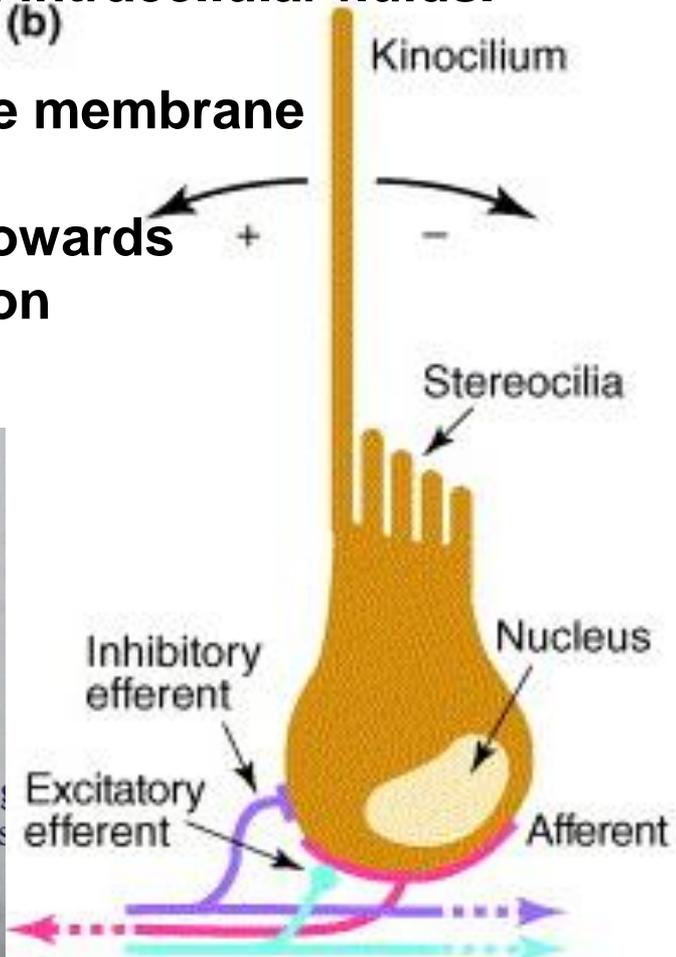


Semi circular canals and utricle and saccule are mainly responsible for the maintenance of equilibrium while the saccule and lagena are site for the sense of hearing

The hair cells are sensitive to mechanical deflection of hairy processes. electrical potential exist at the apical and baso-lateral ends of the cells, due to difference in ionic contents of extra and intracellular fluids.

Deflection of cilia cause flow of ions across the membrane

Afferent fibers excited when stereocilia bend towards kinocilium, while deflection in opposite direction inhibit the afferent fibers.



Auditory mechanism in inner ear

The density of fish body and water are similar. In response to sound, fish's body follows the motion of the water molecules. However, the otolith lag behind the rest of the body because of their higher density and weak suspension.

Above 50 to 100 Hz, an otolith, behaving like a damped harmonic oscillator, can be considered to be immobile.

The result is that hair cells oscillate with respect to otolith and hair bundles are deflected. This mechanism is referred to as direct stimulation of the ear.

Deflection of cilia cause flow of ions across the membrane and depolarization of hair cells. The depolarization is followed by an increase in the firing rate of the nerve fibers transmitting the sensory information to the brain.

Chemosensory Organs

Fish have two well defined chemical-sensing system

1. Gustatory System (Taste)

2. Olfactory System (Smell)

Chemosensory Behavior

Feeding 

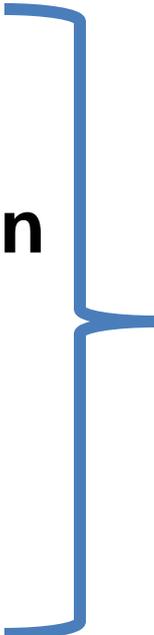
Gustation

Detecting Danger

Non sexual Social interaction

Orientation

Reproductive synchrony

 Olfactory

Gustatory System

The sense of taste is generally defined as that portion of the nervous system associated with sensory cells of taste buds.

Although, fishes have dense concentration of taste buds in their mouth, the distribution of these structure may frequently include the gills and exterior surface of the animal.

The gustatory sense of fishes is associated with distinct cranial nerves (VII, IX, X), all of which are projected to different areas of brain.

Taste Buds

- ✓ Sensory cells of taste buds present on the external body, lips and rostral palate form synapse with facial (cranial nerve VII) neurons
- ✓ Sensory cells of taste buds present along the floor of the oral cavity and gill rakers of first gill arch form synapse with glossopharyngeal (cranial nerve IX) neurons
- ✓ Sensory cells of taste buds present more posterior in pharynx synapse with vagal (cranial nerve X) neurons
- ❖ Taste buds that synapse with cranial nerve VII are important in appetitive (food search) feeding activity
- ❖ Taste buds that synapse with IX and X cranial nerves are important in consummatory (ingestive and swallowing) feeding behavior.



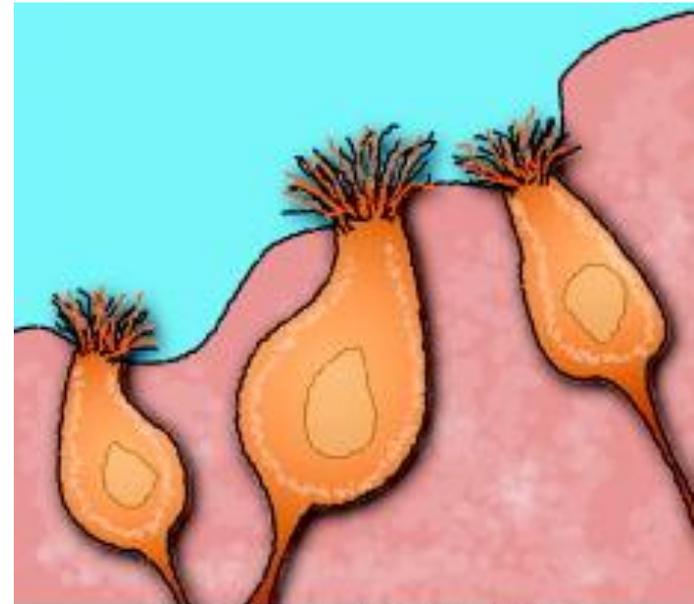
Olfactory System

Olfactory system mediates responsiveness to a much broader range of stimuli, including learned food odors, geographic locations and pheromones.

The variety of stimuli detected by the olfactory sense are much greater than gustatory system.

Olfactory sensitivity is mediated by a single cranial nerve (**the olfactory nerve**) projected directly to the brain and regenerate throughout the life of animal.

In fishes, olfactory receptor cells are located in olfactory epithelium which covers much of the surface of olfactory rosette, a structure found within the olfactory chamber of fish rostrum

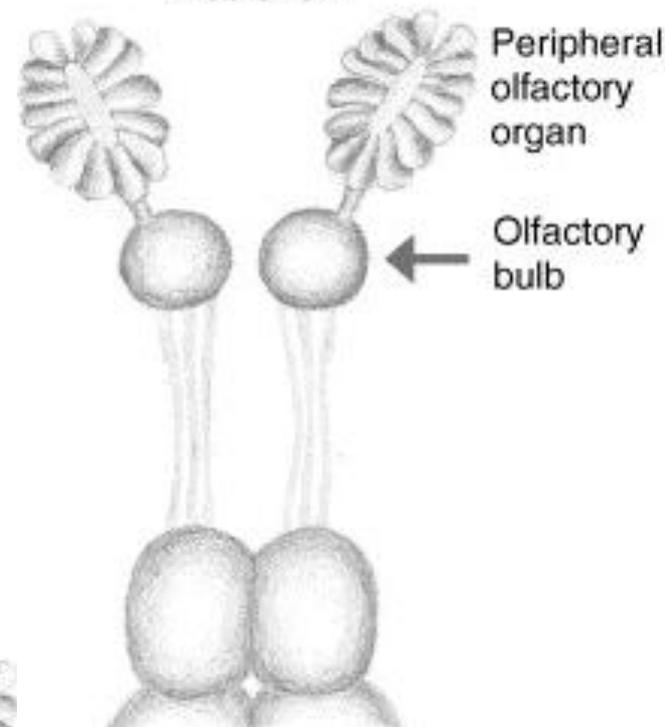
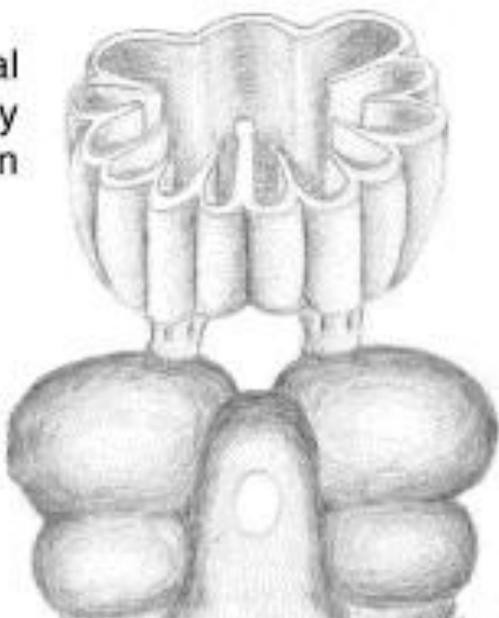


Olfactory sensory neurons

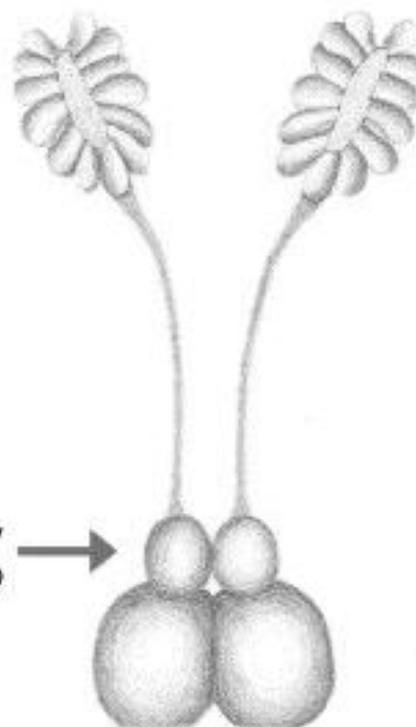
A

Lamprey

Zebrafish

Peripheral
olfactory
organOlfactory
bulbPeripheral
olfactory
organOlfactory
bulb

Salmonid

Peripheral
olfactory
organOlfactory
bulb

Olfactory Stimuli

❖ **Amino acids**

❖ **Bile acids**

❖ **Gonadal steroids and derivatives**

❖ **Prostaglandins**

❖ **Various alcohol, amines, carboxylic acids, nucleotides, aromatic hydrocarbons**

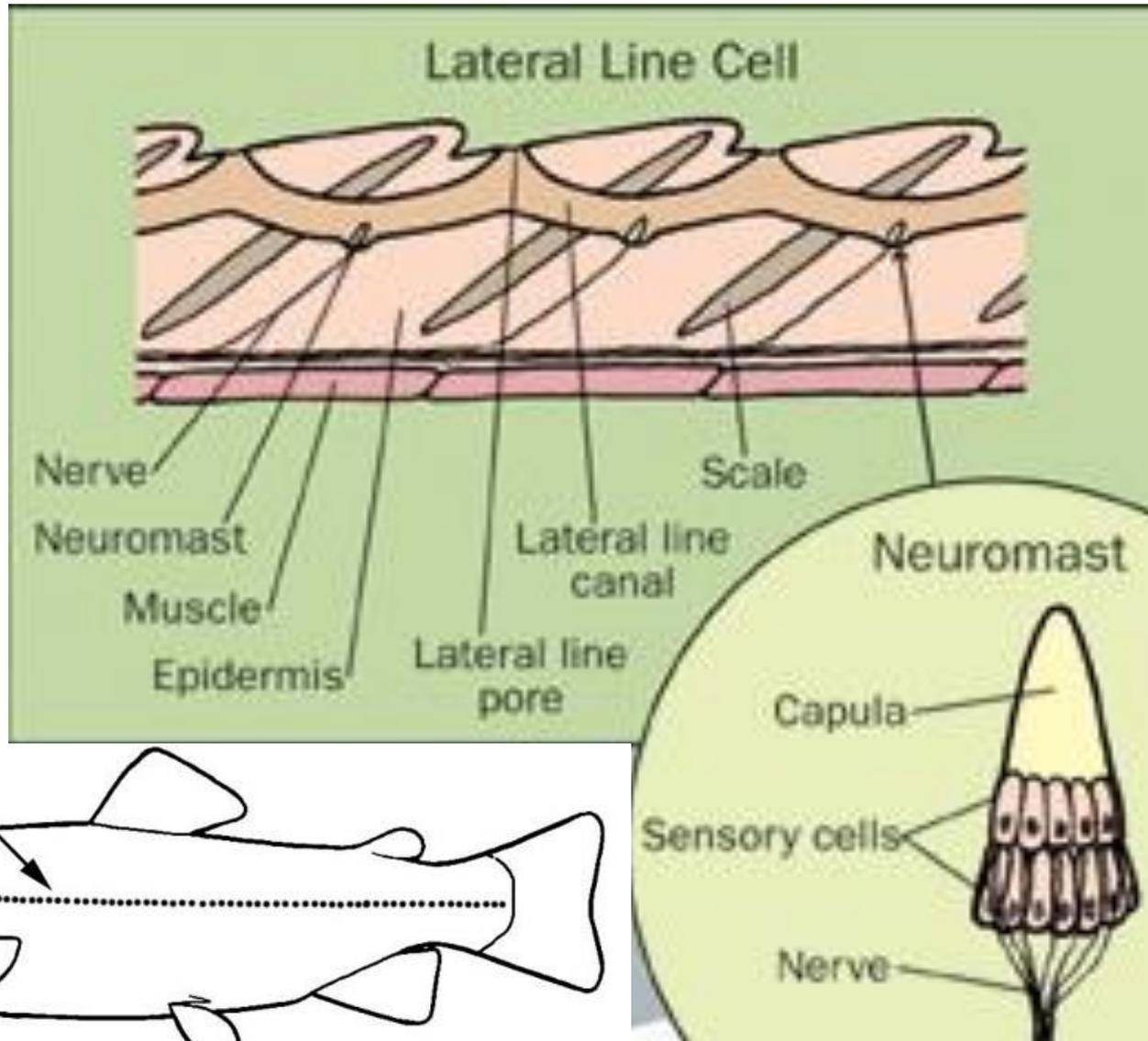
Lateral Line System

Lateral line system comprises specialized sense organs work as a mechano-sensory organ

The lateral line canals are arranged in a definite pattern in cephalic region. A prominent lateral line canal extend along each side of the body from head to tail and several branches are present in the head region.

In primitive fishes, canals are in the form of grooves while in chondrichthyes and teleost they are closed tubes full of mucus which are open to exterior by means of tubules or pore at different intervals.

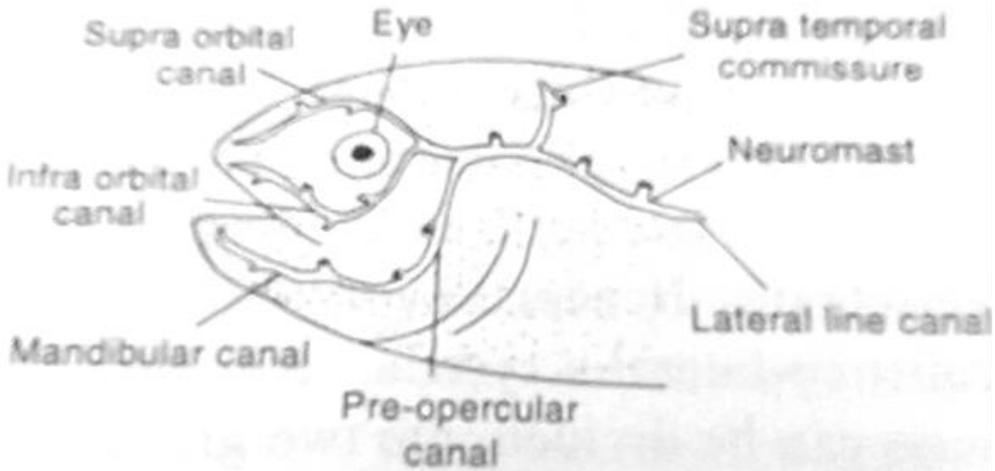
Lateral Line System in Teleost



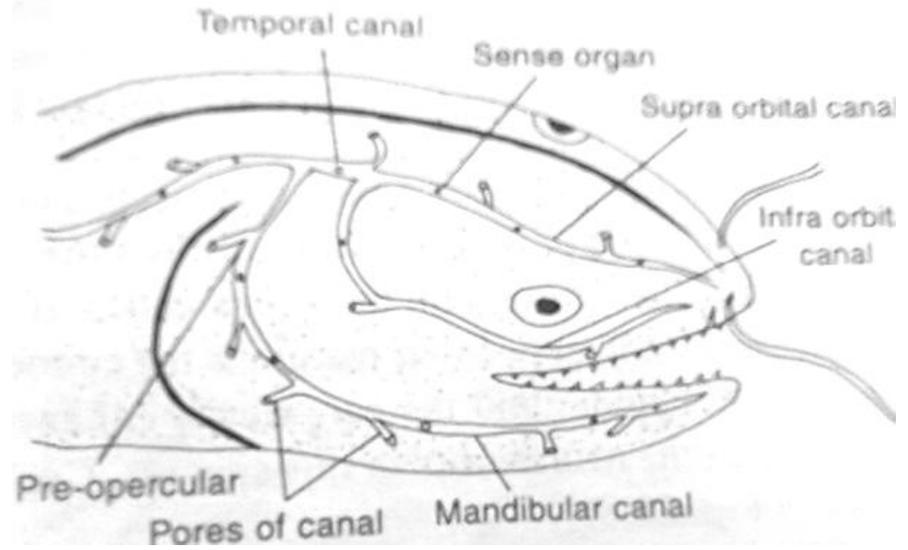
Cephalic Lateral Line canals

Cephalic lateral line canals generally divided into three branches

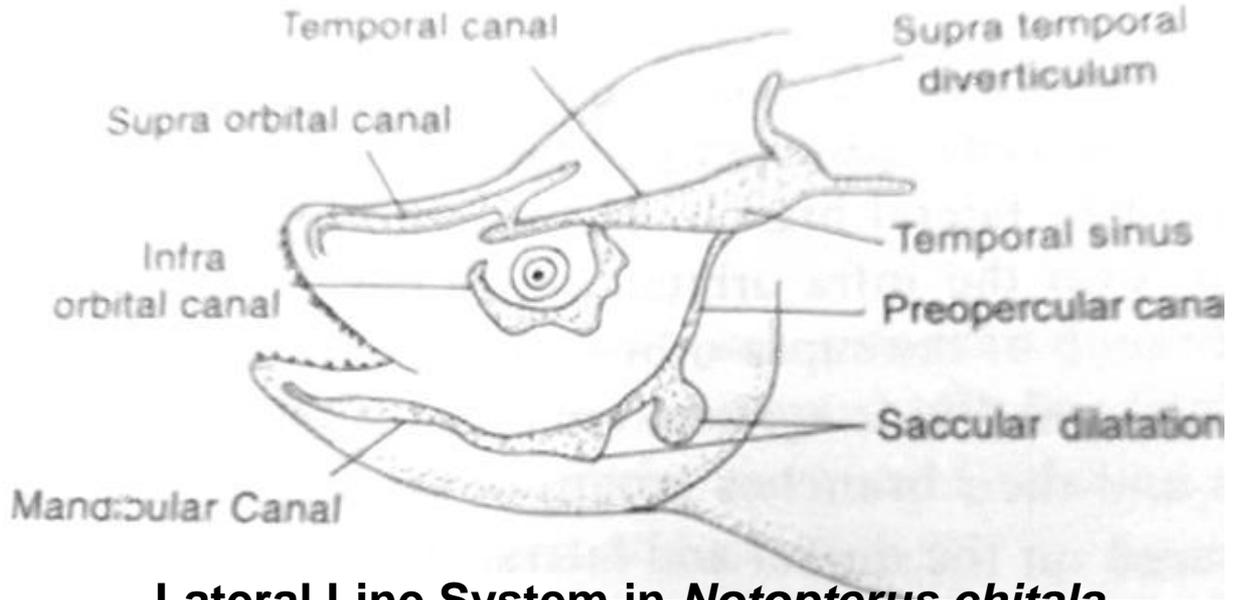
1. Supra-orbital (above eye, going to snout)
2. Infra-orbital (below eye, reaching upto snout)
3. Hymandibular (behind the eye, going upto lower jaw)



Lateral Line System in *Amia*



Lateral Line System in *Wallago attu*

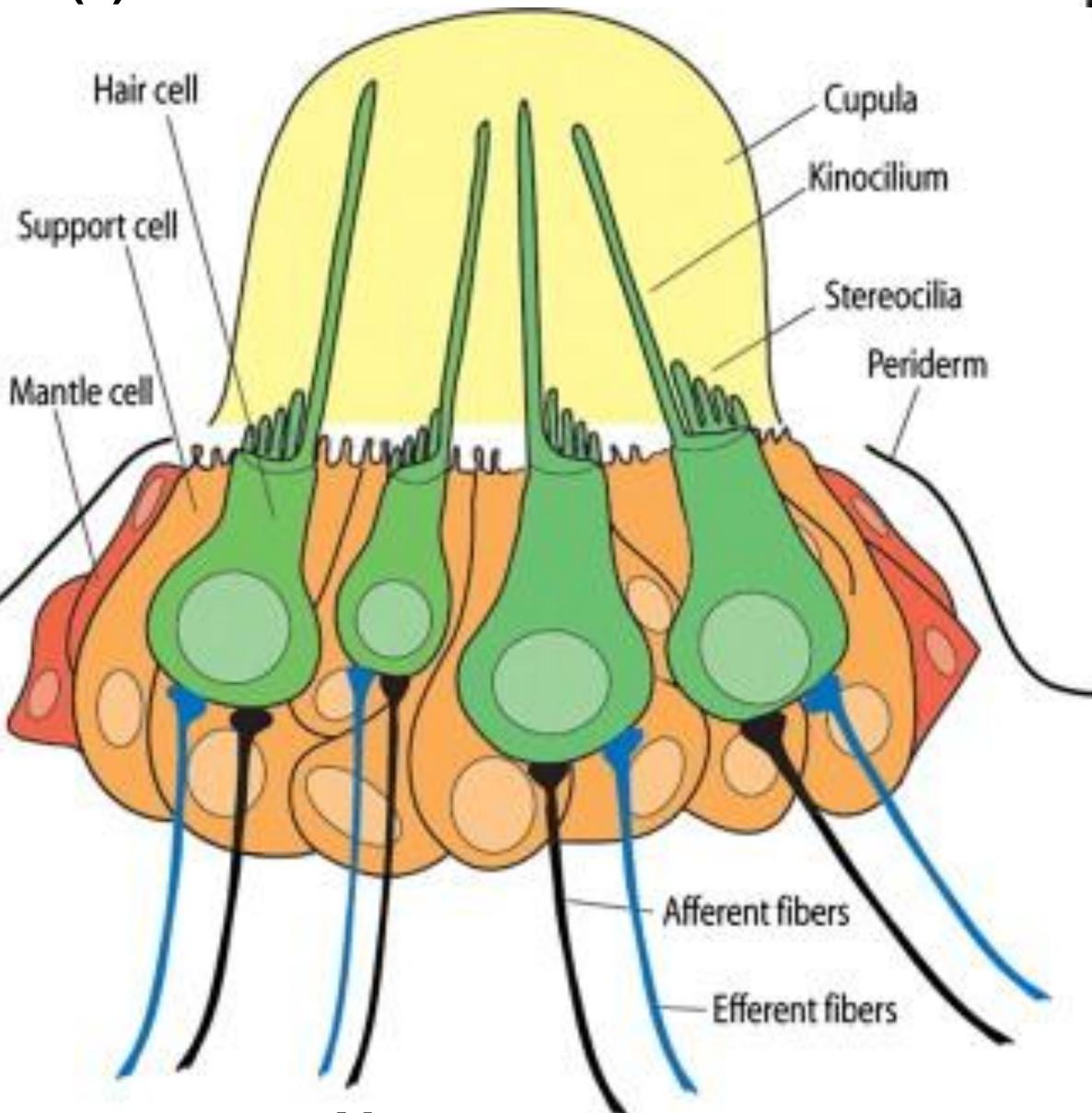


Lateral Line System in *Notopterus chitala*

Structure of Neuromast

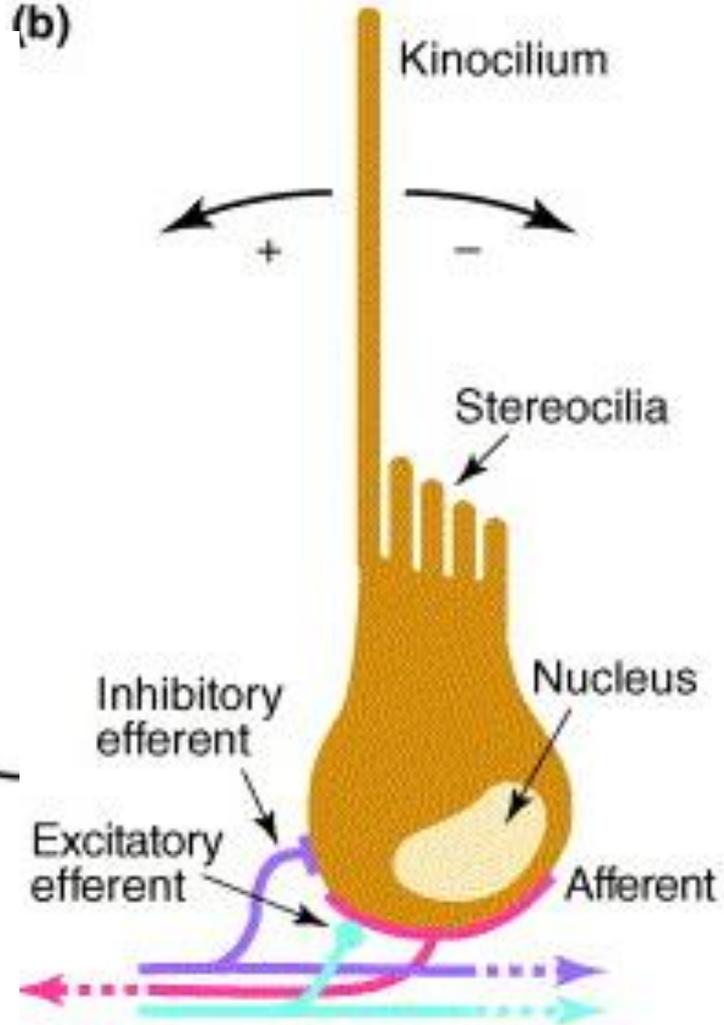
- Each neuromast is a group of cell consisting of sensory cells, supporting cells and basal cells.
- The sensory cells possess a bundle of cilia (stereocilia and kinocilium) on the apical surface and called hair cells.
- The stereocilia are full of microfilaments and become longer from one end of the bundle to the other.
- The Kinocilium is situated eccentrically at the margin of the bundle and has 9+2 arrangement of microtubules.
- The hair project above the surface of the epithelium and the cells are enclosed in a gelatinous tube called cupula. The cupula lies free and can be moved by the water or by mucus.
- Sensory cell is connected to the central nervous system by an afferent and an efferent nerve fibers.
- The cell is sensitive to deflection and is a mechano-receptor.

(a)



Neuromast

(b)



Sensory Hair Cell

Sensory Mechanism in Neuromast

Cupula surrounding the hair cells of neuromast move freely when water surrounding it is set in motion.

Due to the movement of fish, pressure gradient or wave generated which results into oscillation and hair bundles of sensory cells are deflected.

Deflection of cilia cause flow of ions across the membrane and depolarization of hair cells. The depolarization is followed by an increase in the firing rate of the nerve fibers transmitting the sensory information to the brain.

Function of Lateral Line system

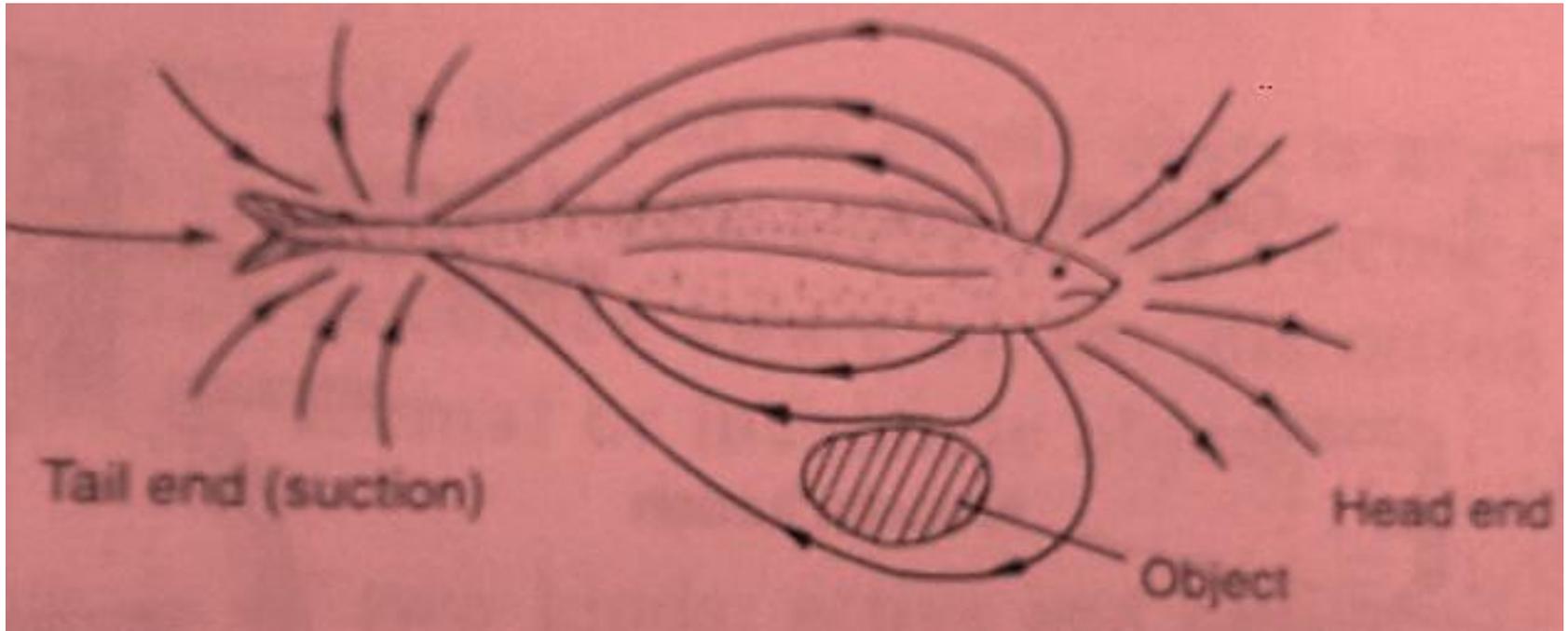
Neuromast of lateral line system are scattered all over the body and perform the function of mechano-receptors

The fish is able to detect and locate animal or inanimate mobile or immobile objects with the help of neuromast.

These organs are of considerable help in detecting the prey or food, avoiding predator, for schooling and for intraspecific communication.

Neuromast function as hydrodynamic detector, being sensitive to pressure gradient or waves generated in water due to the movements of fish or prey.

Thus, these organs function as “distant touch receptor” and fish can sense an object at a distance in dark, muddy water



Distortion of line of pressure by a solid object

Mauthner cell

The Mauthner cell was first identified by the Viennese ophthalmologist Ludwig Mauthner in the teleost fish for its associated neural circuit which mediates an escape response called the C-start or C-startle to direct the fish away from a predator.

The **Mauthner Cells** are a pair of big and easily identifiable neurons (one for each half of the body) located in the rhombomere 4 of the hindbrain in fish that are responsible for a very fast escape reflex (in the majority of animals - a so-called C-start response). The cells are also notable for their unusual use of both chemical and electrical synapses

Electro-receptor Organs

They are highly sensitive to the electric field and are used for electro communication, electro location and social signaling.

The electroreceptor show considerable variation in their morphology in different species and are distributed all over the skin of the fish.

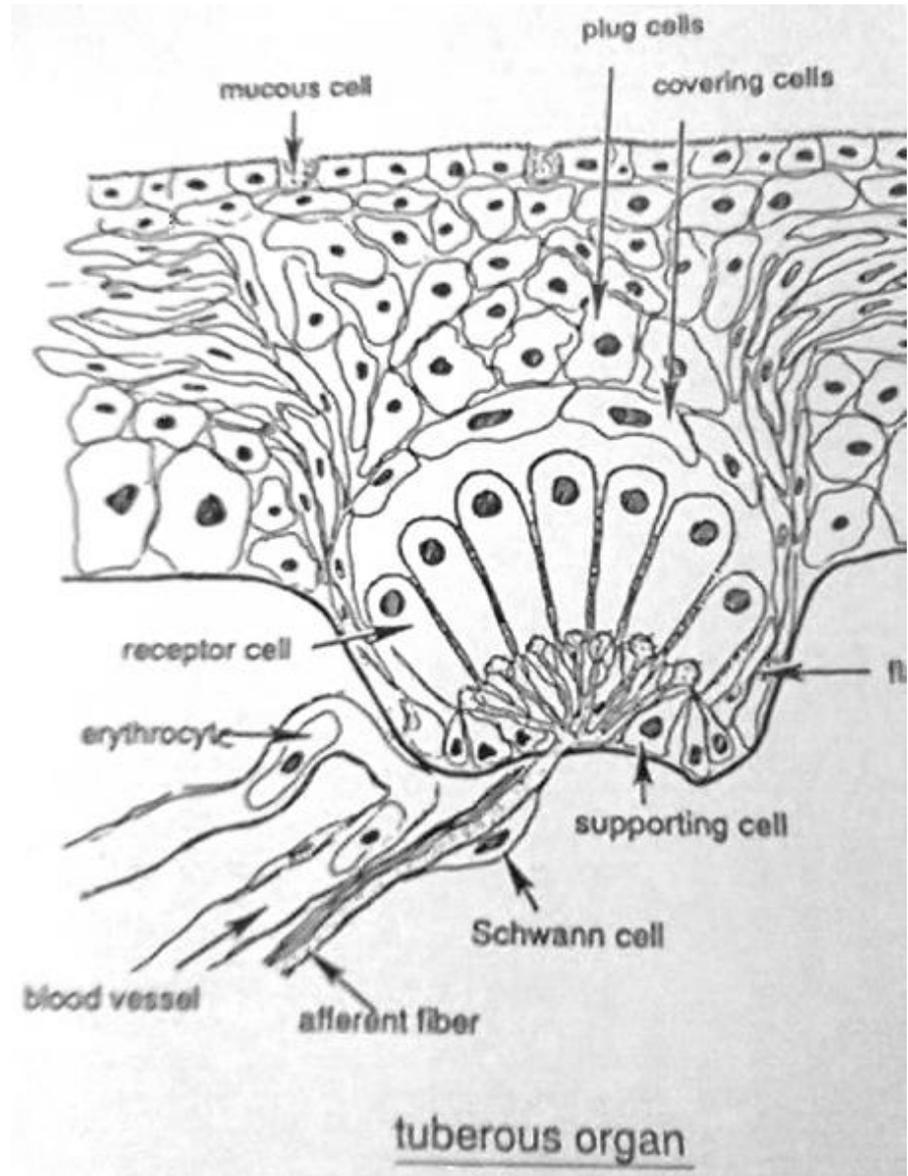
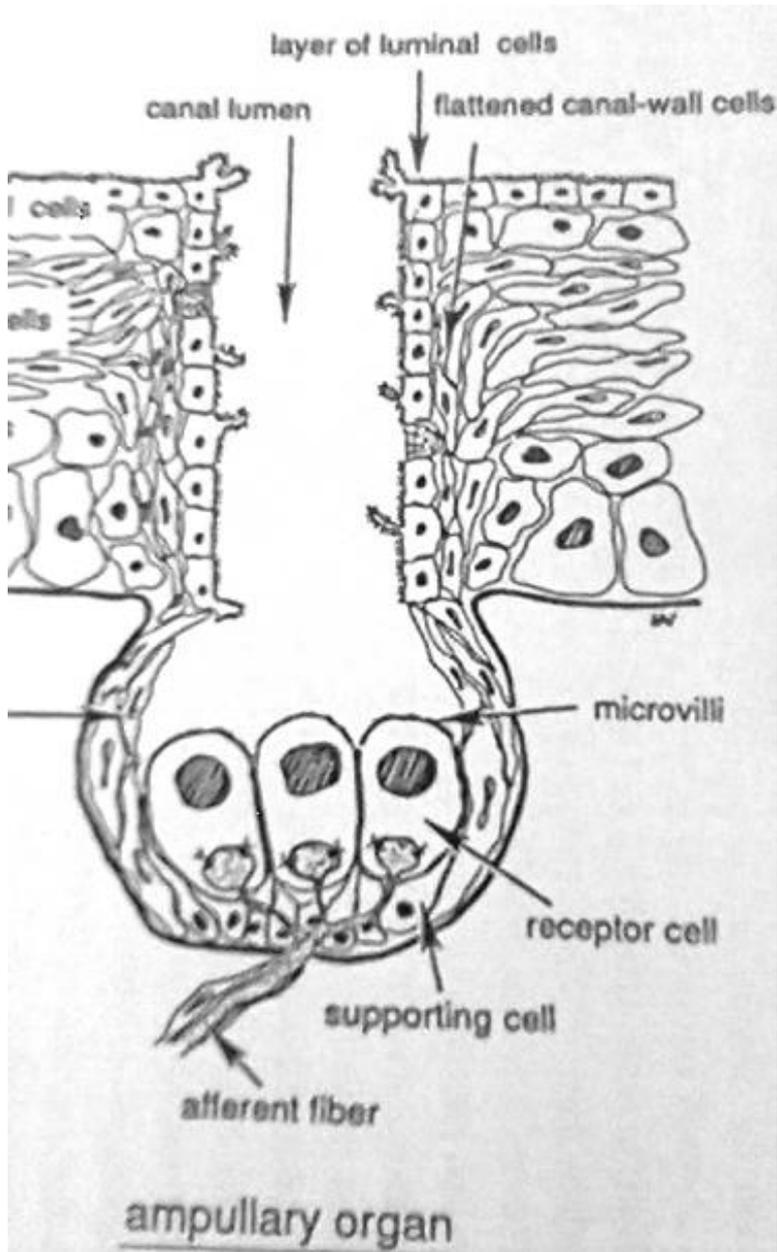
In fishes, electroreception is found among all non teleost taxa except Myxiniiformes and Holostei. Two kinds of electroreceptors are found in fishes.



a. The ampullary organs: They respond to signals of low frequencies upto 50 Hz

b. The Tuberous organs: they are high frequency receptors and are restricted to electric fishes that produce their own high frequency electric signals.

Structure of Electro-receptors



Function of Electroreceptor

The electro-receptors enable the fish to locate objects at a distance, as the fish possessing them is far more sensitive to the electric field than those without them. The fish become aware of any distortion in the electric field caused by another animal or inanimate object.