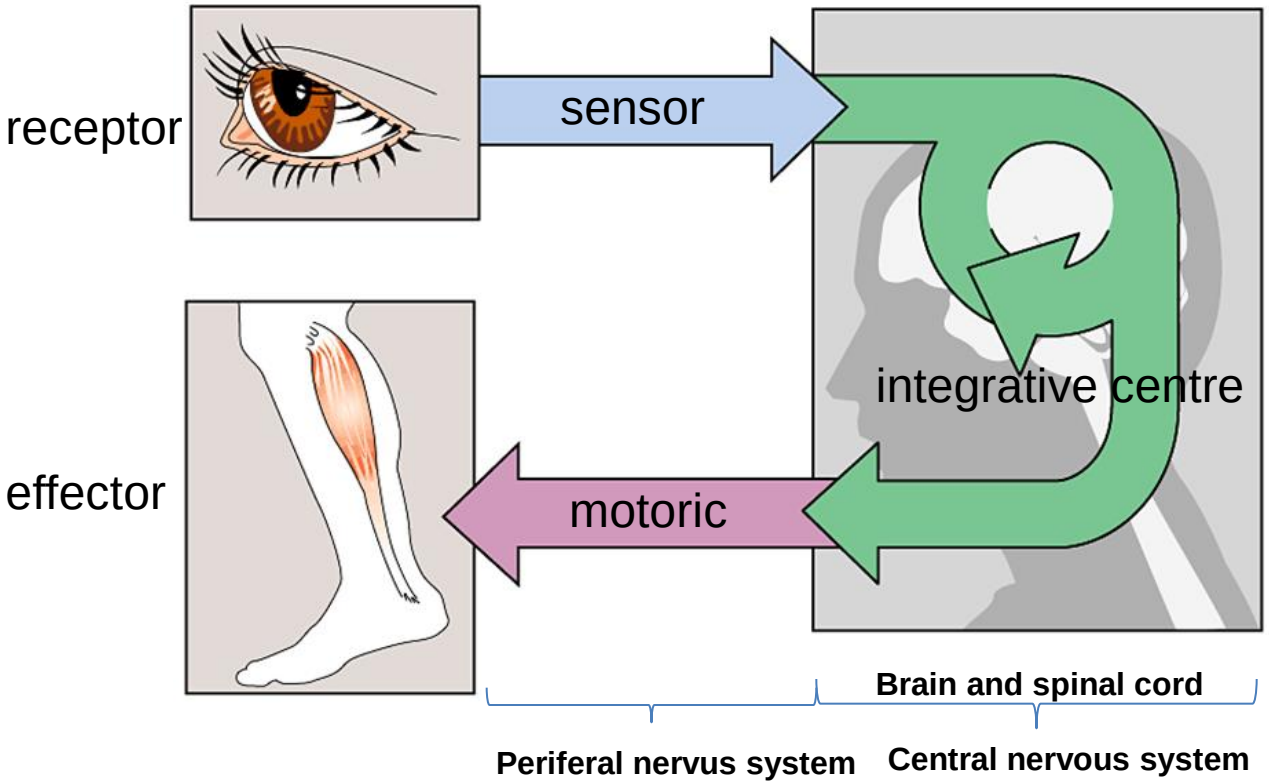
Nervous system

Role

- the major controlling, regulatory, and communicating system in the body.

- the center of all mental activity including thought, learning, and memory

- together with the endocrine system, it is responsible for regulating and maintaining homeostasis.



central nervous system is made up of the brain and spinal cord

peripheral nervous system is made up of nerves that branch off from the spinal cord and extend to all parts of the body

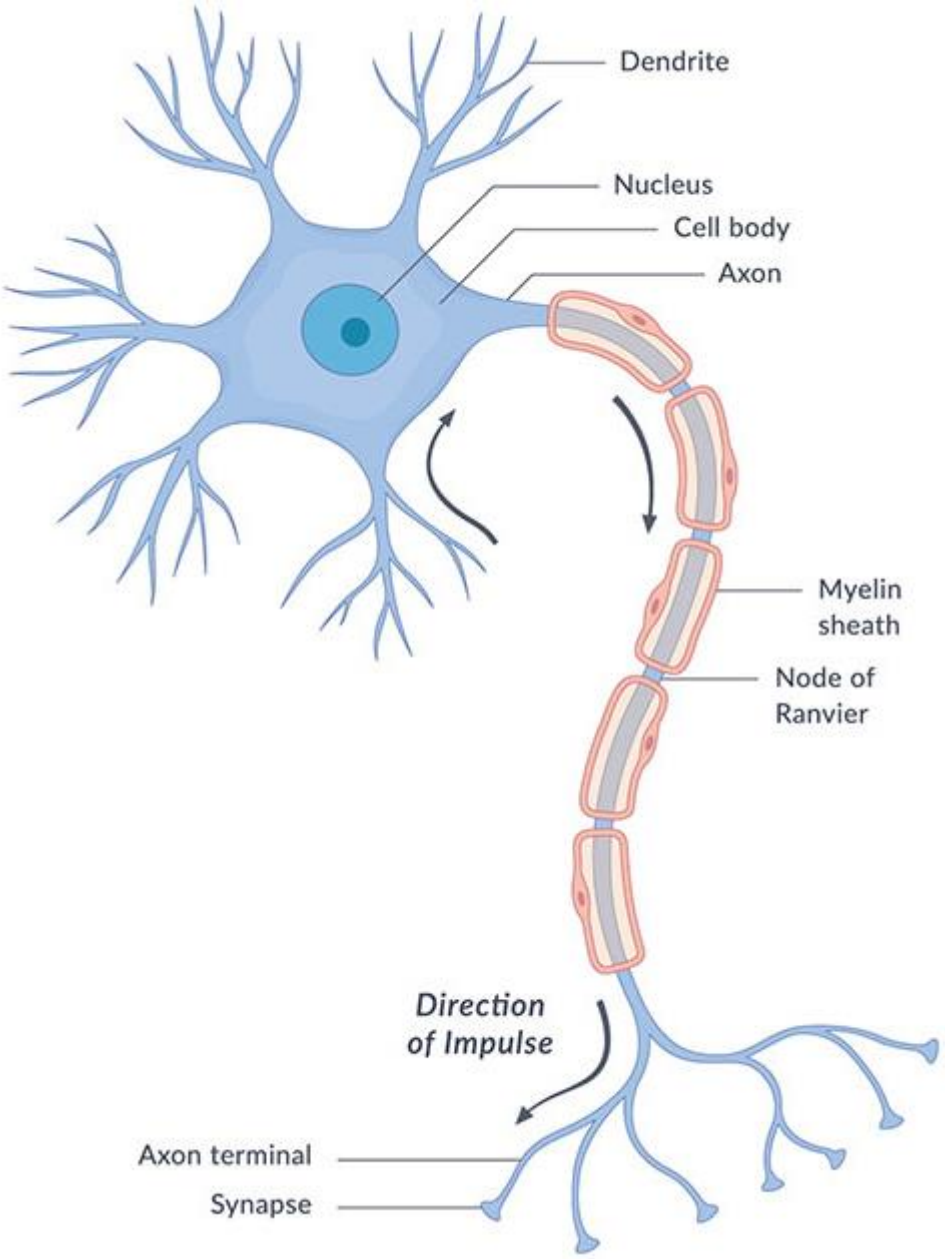
Built of:

Nerve cells (neurons) - receive and transmits signals

Glia cells – support, protection, feeding

- non-neuron cells,
- keep the nervous system working properly help support and hold neurons in place
- protect neurons
- create insulation called myelin, which helps move nerve impulses
- repair neurons and help restore neuron function
- trim out dead neurons
- regulate neurotransmitters

Nerves - bundles of axons

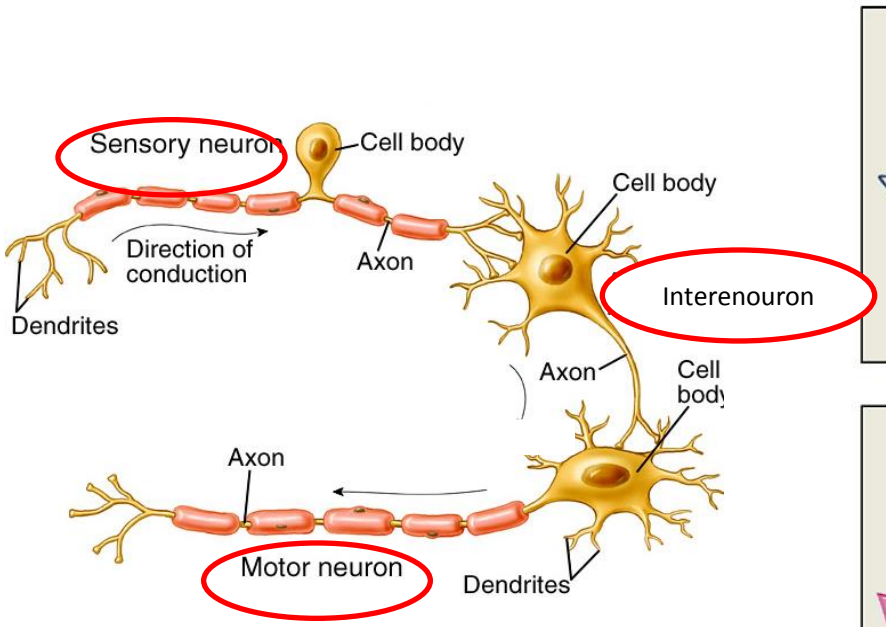


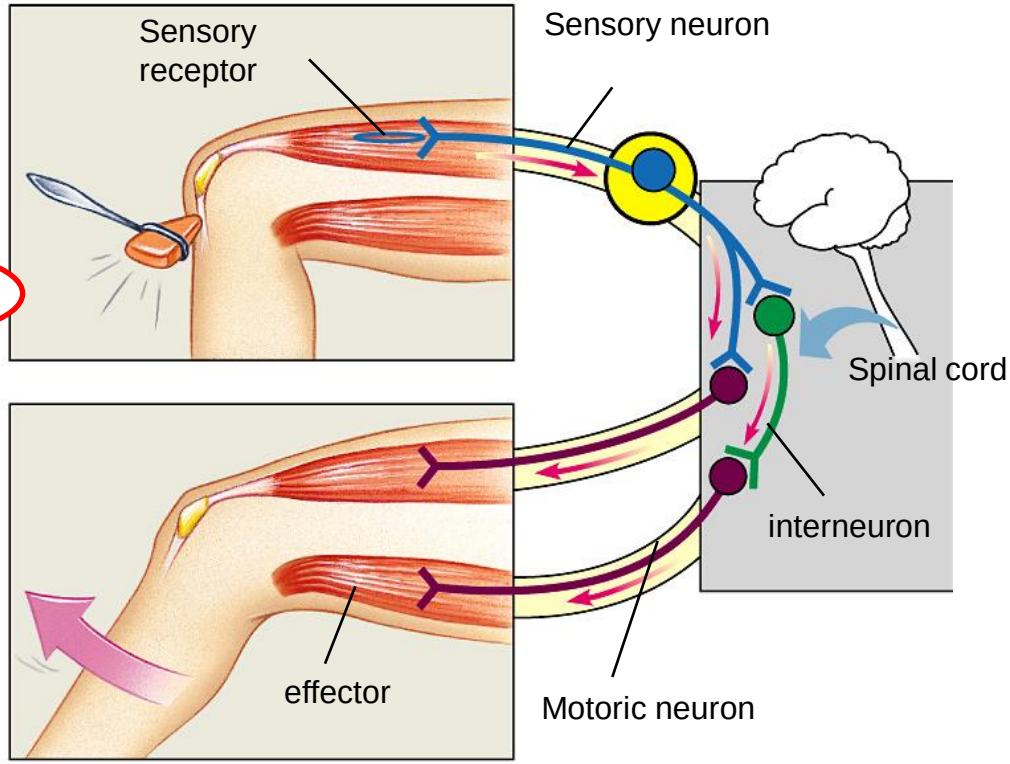
Neurons could be:

sensory – receive impulse – transmit into „local” centre

interneurons – receive and transmit into „main” centre

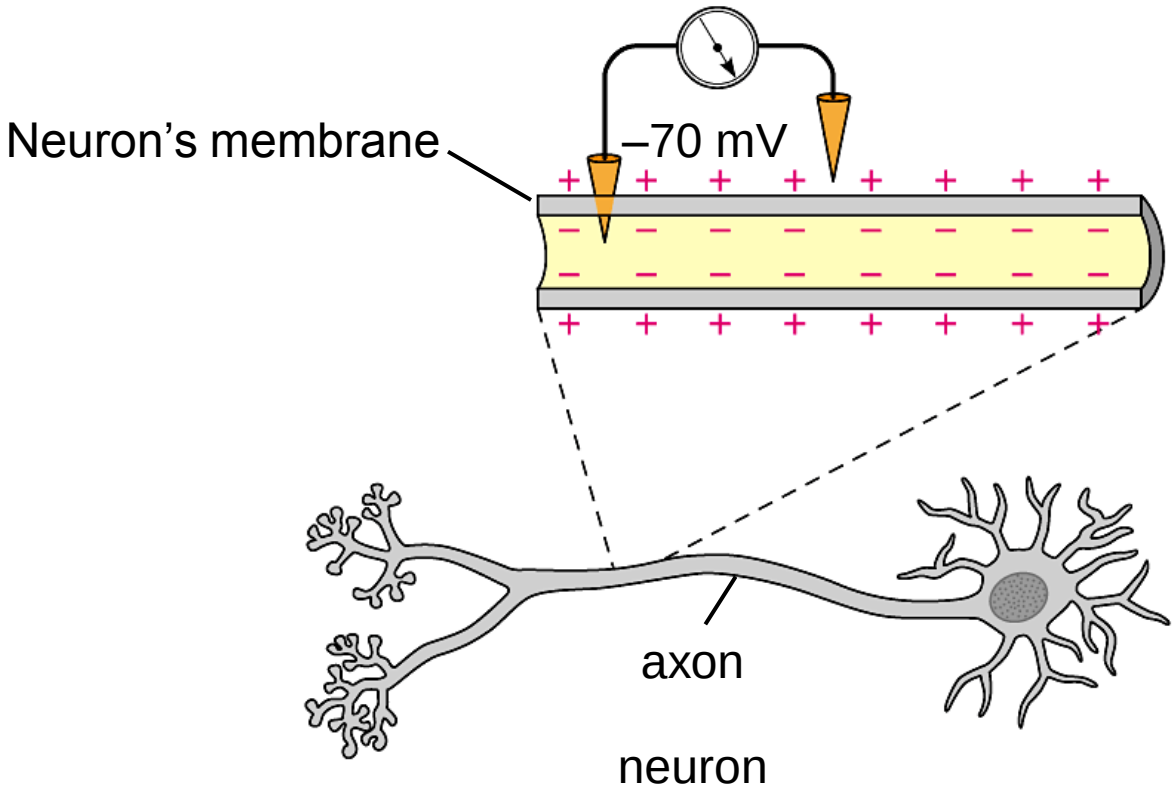
motoric – transmit to effector (e.g., muscle)



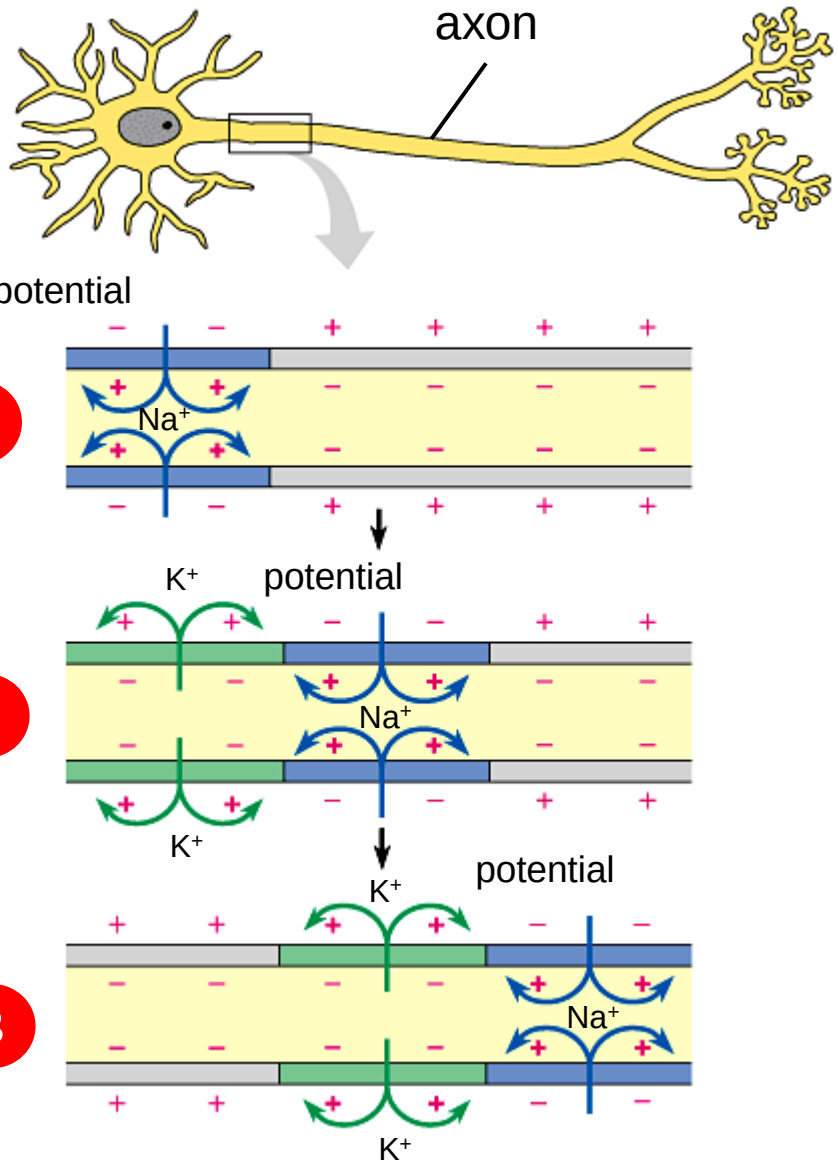


Receiving and transmitting impulses

- When there is no impulse – inside the neuron is negatively charged, and outside it is positively charged
- Difference in the potential (outside-inside) **resting potential** = cca -70 mV



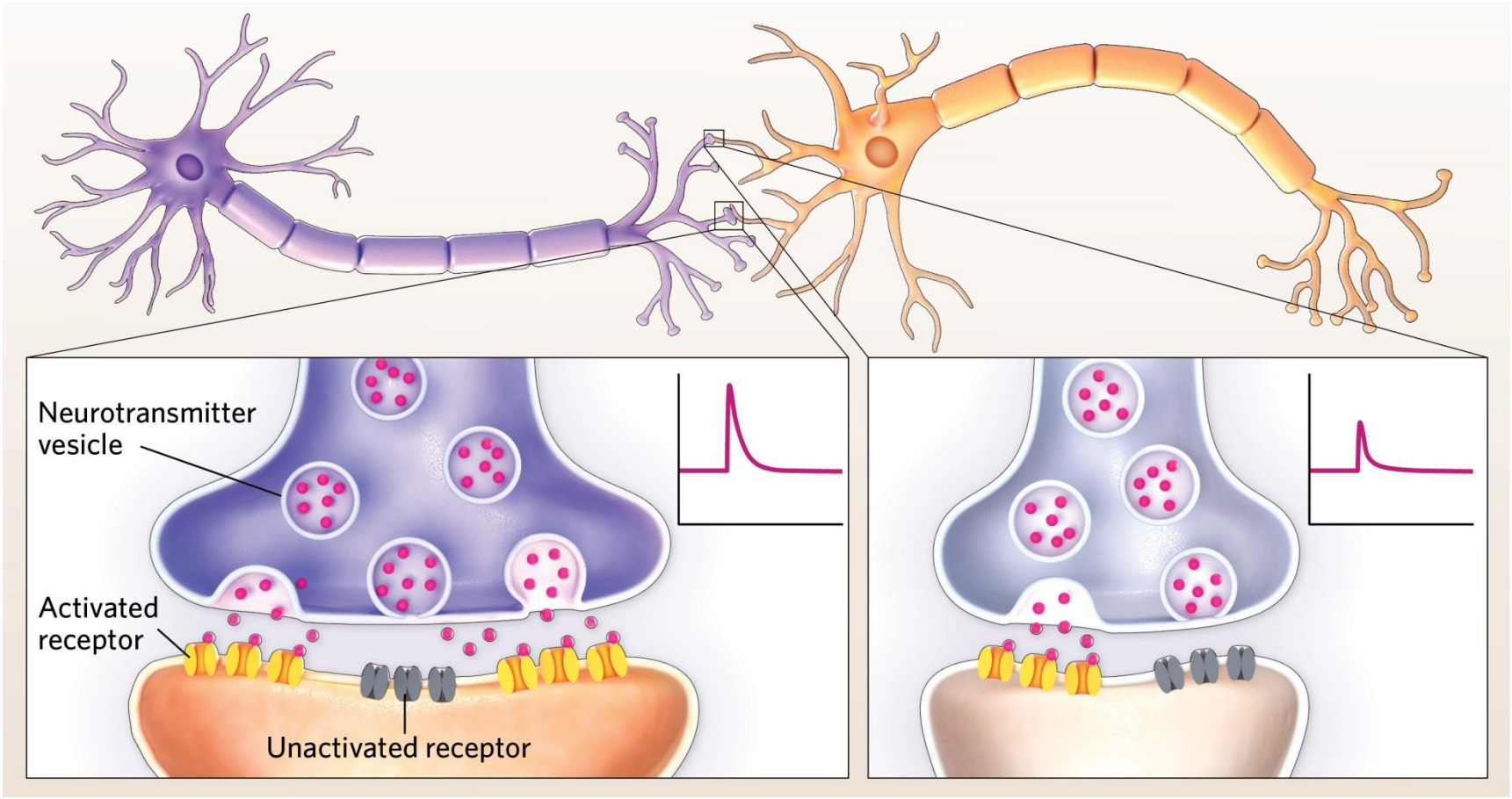
- When impulses are propagated along the axon electrical charge is „jumping” along the axon due to the diffusion of Na^+ and K^+ ions into and out of cell



- If impulse is stronger – „jumping” will be faster

- Fatter axons transmit impulse faster and existence of myelin sheath helps as well

Chemical synapse



- neurotransmitter e.g., acetylcholine
- Stopping of the impulse – acetylcholine esterase

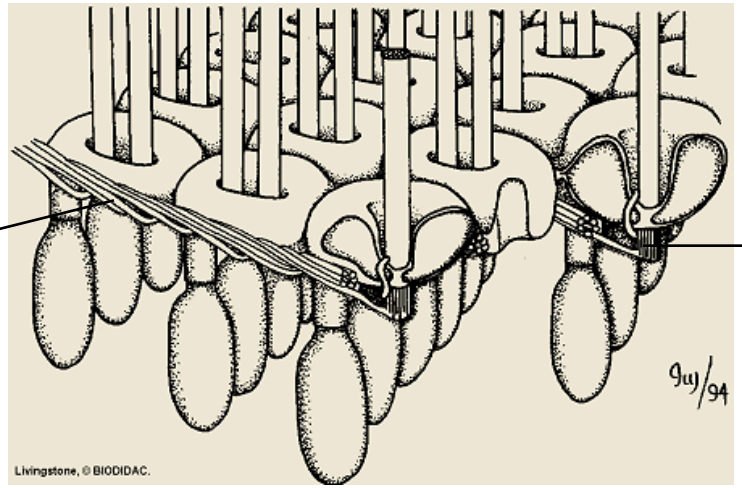
Overview per animal groups

- All cells react to stimuli, Protists and Sponges don’t have nervous system, still they react

- Development of nervous system is connected to animals' activity and body size

PROTISTS

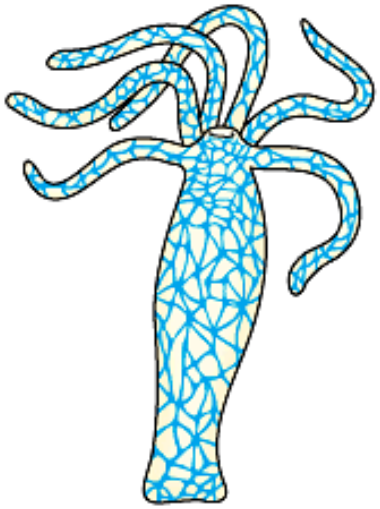
Paramecium pelikle



► invertebrates – nervous system (generally) on the ventral side

Cnidaria

- **NERV NET-** impulses in all direction



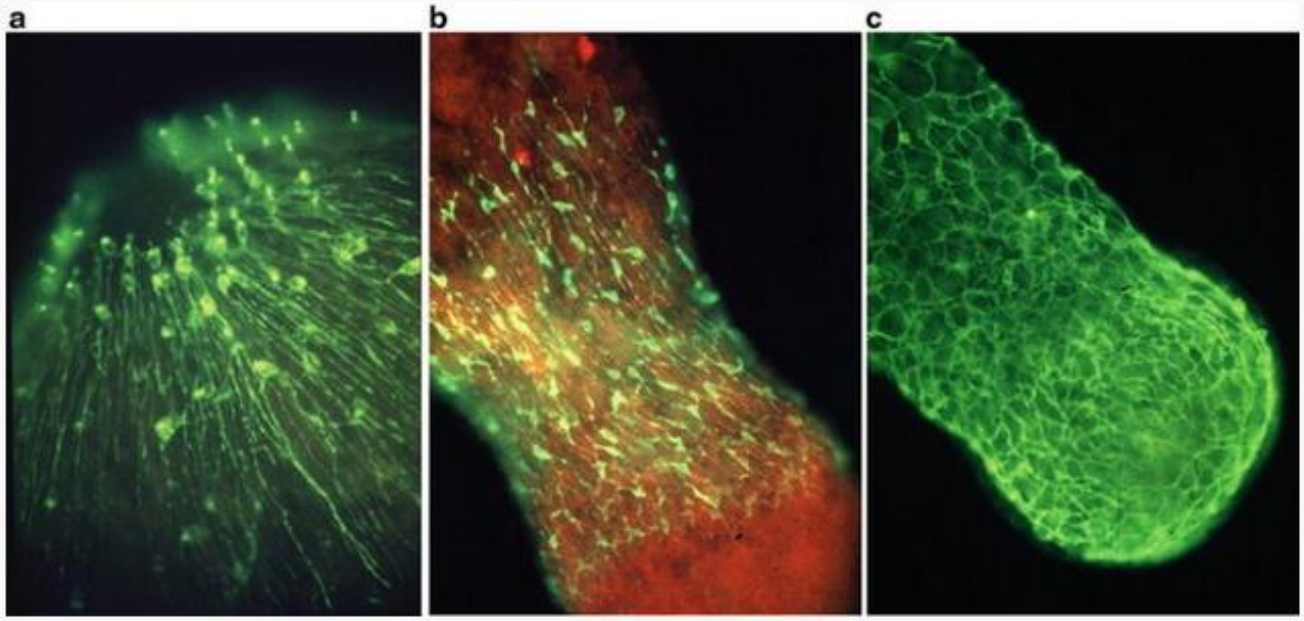


Fig. 6.3
Cnidarians nervous system visualized with different antibodies: a monoclonal antibody, JD1 (**a**), antiserum against neuropeptides, RFamide (**b**), antiserum against neuropeptides, GLWamide (**c**). **a** is hypostome of hydra, and (**b**, **c**) are foot part

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Origin and Evolution of the Nervous System Considered from the Diffuse Nervous System of Cnidarians

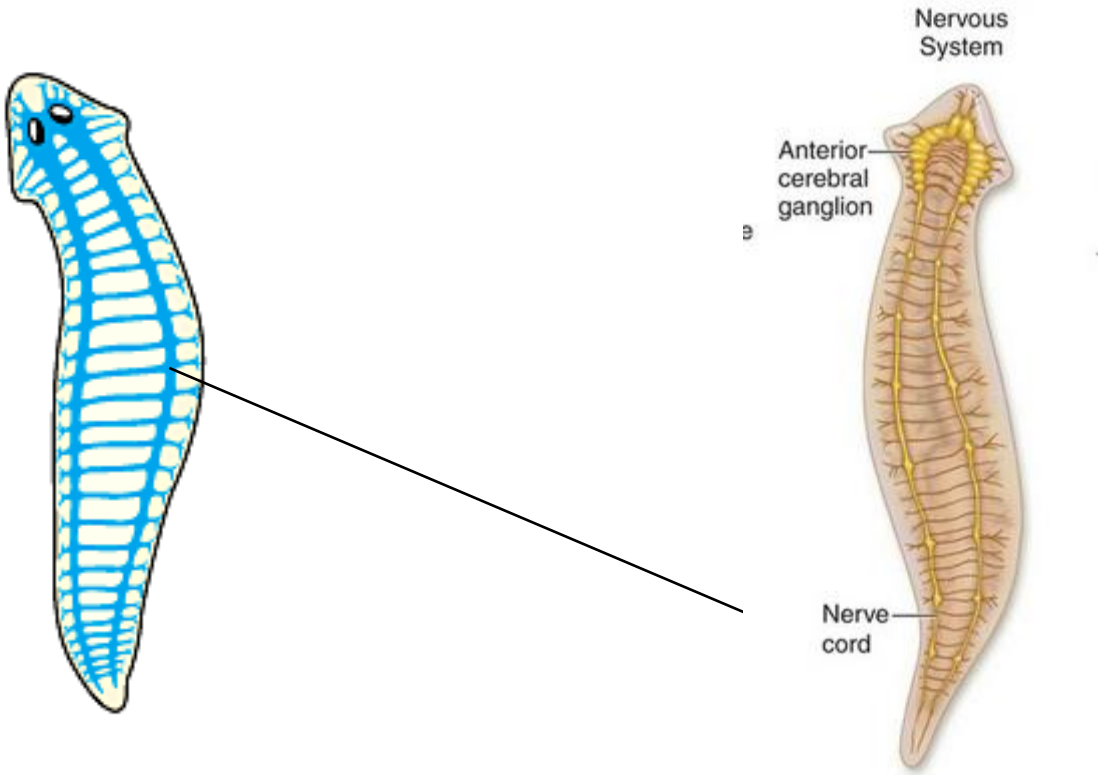
Authors Authors and affiliations

Osamu Koizumi

► acive movement – **cephalisation**

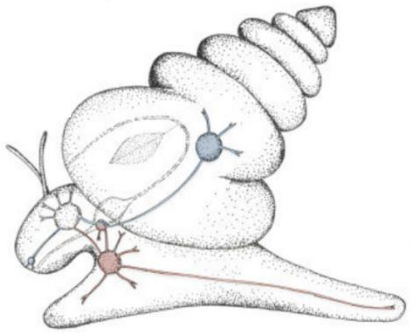
Platodes

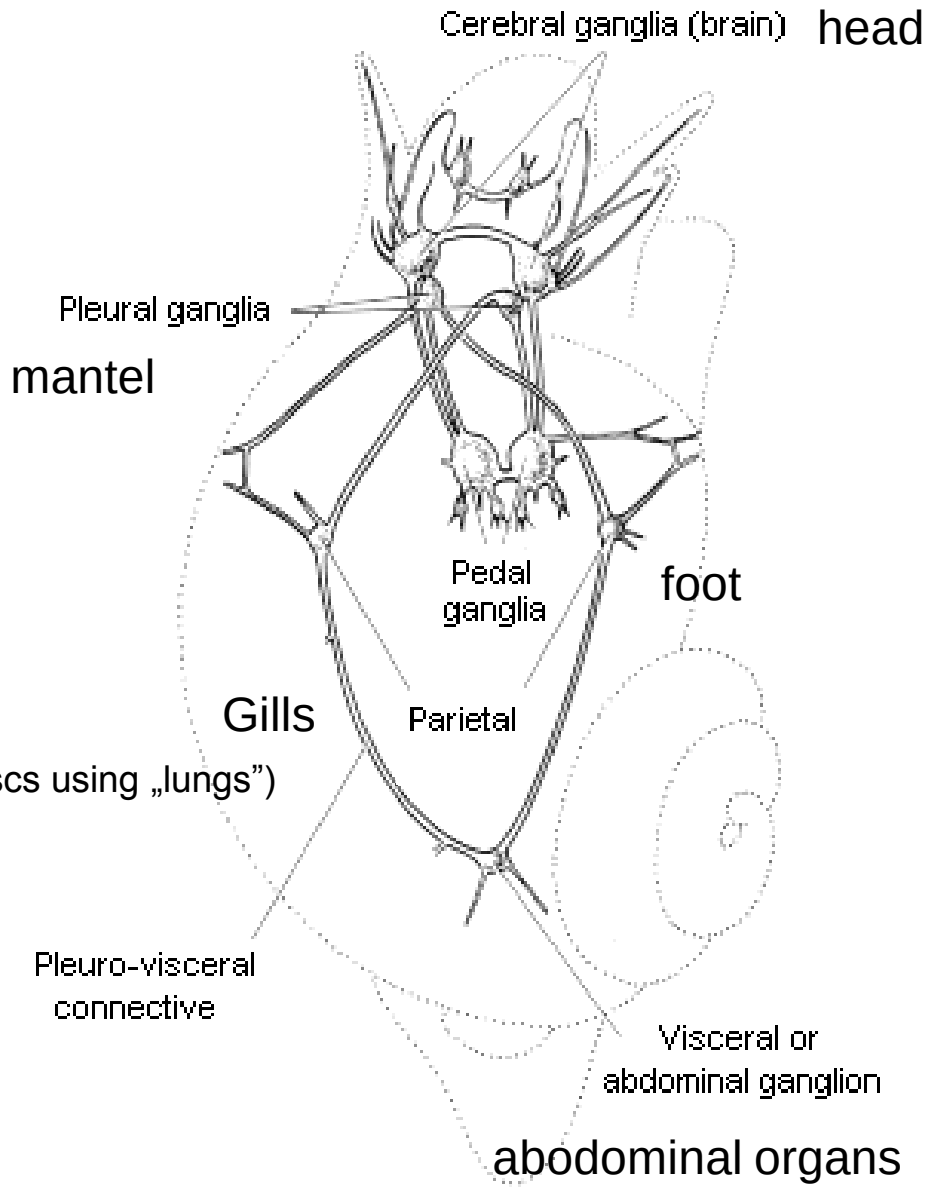
- simple – longitudinal nerve cordes



Molluscs

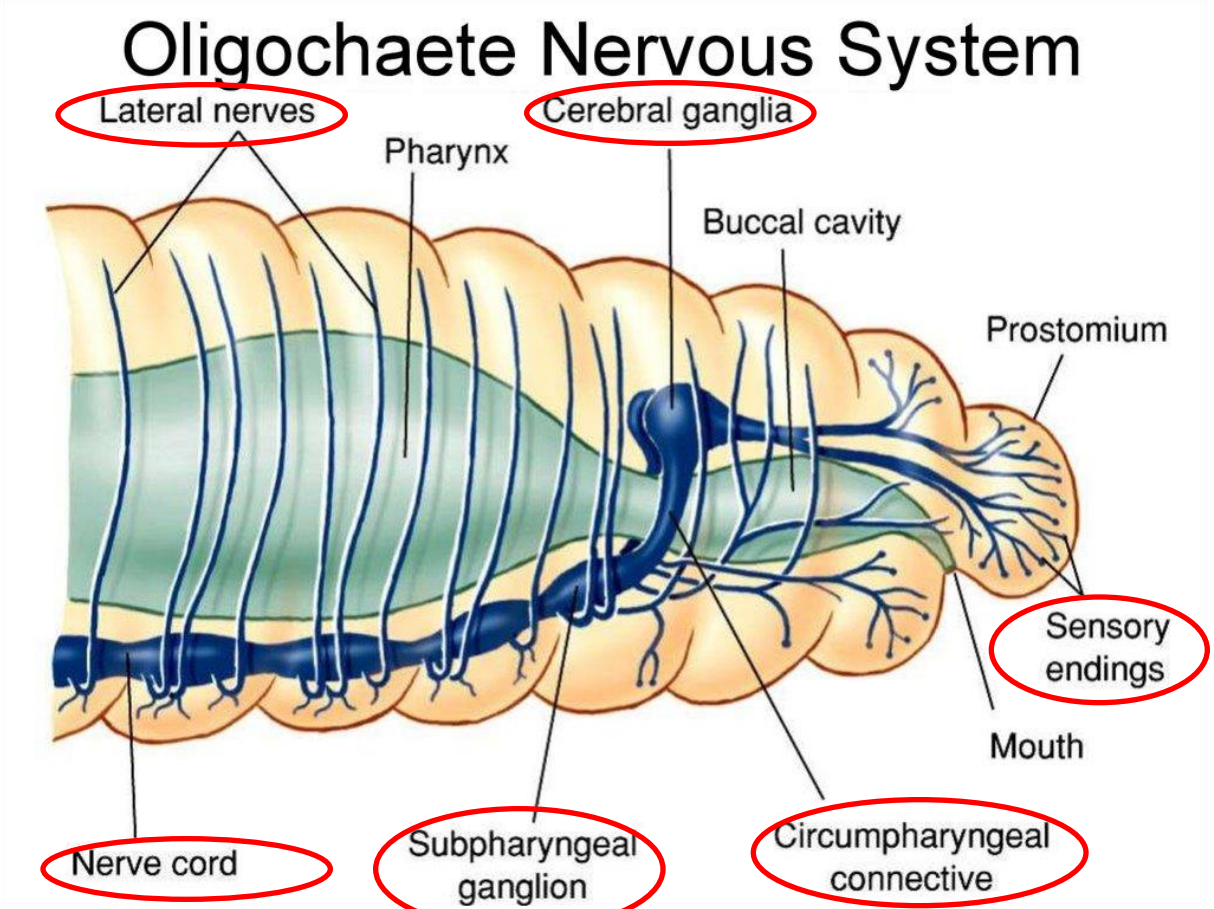
- 5 pairs of ganglia (nerv cells + glia cells)





Annelids

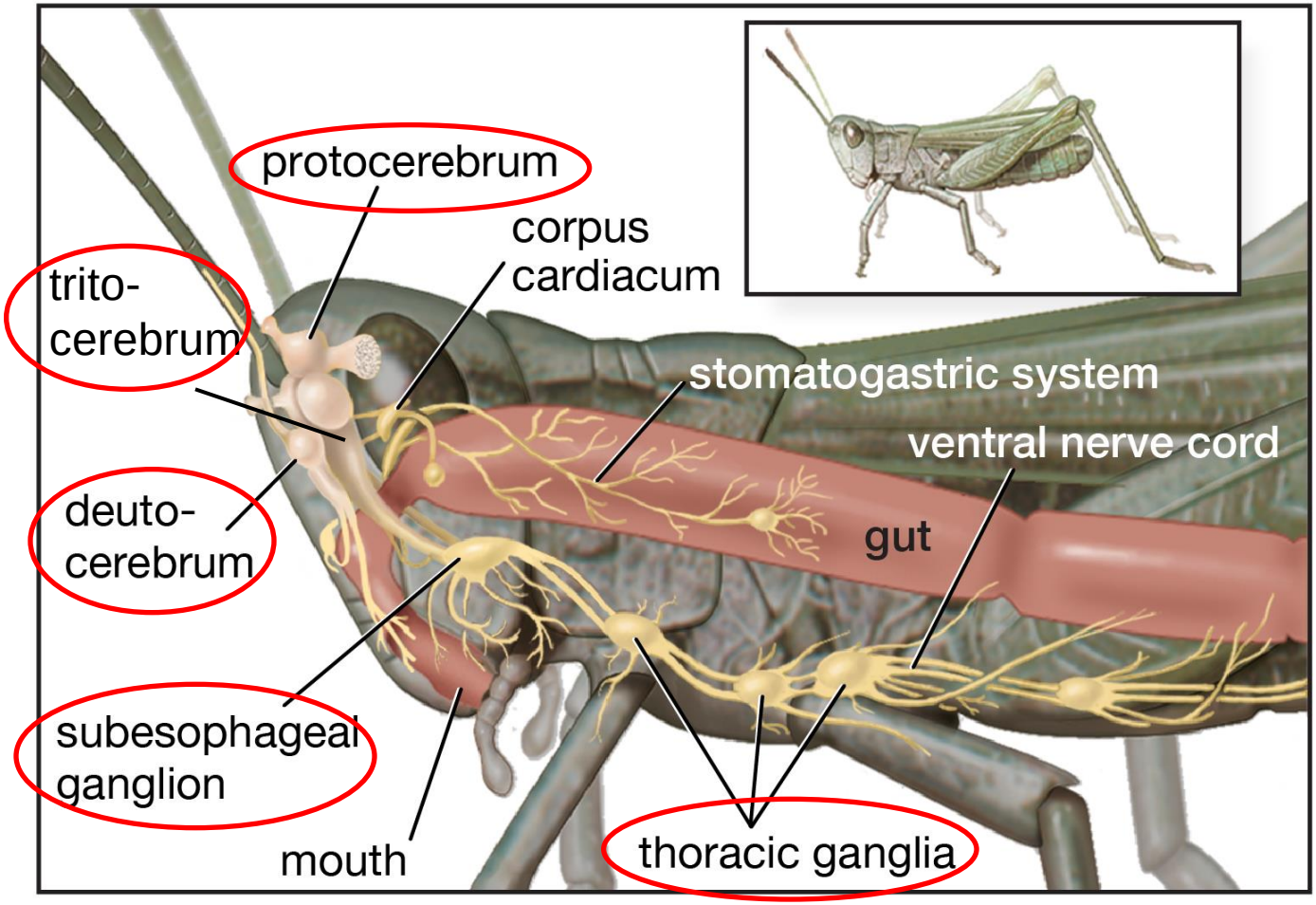
The annelid nervous system consists of **a primitive compact brain in the anterior of the body connected with two ventral nerve cords** that connect with ganglia in each segment. Annelids have evolved specialised sense organs



Arhtropods

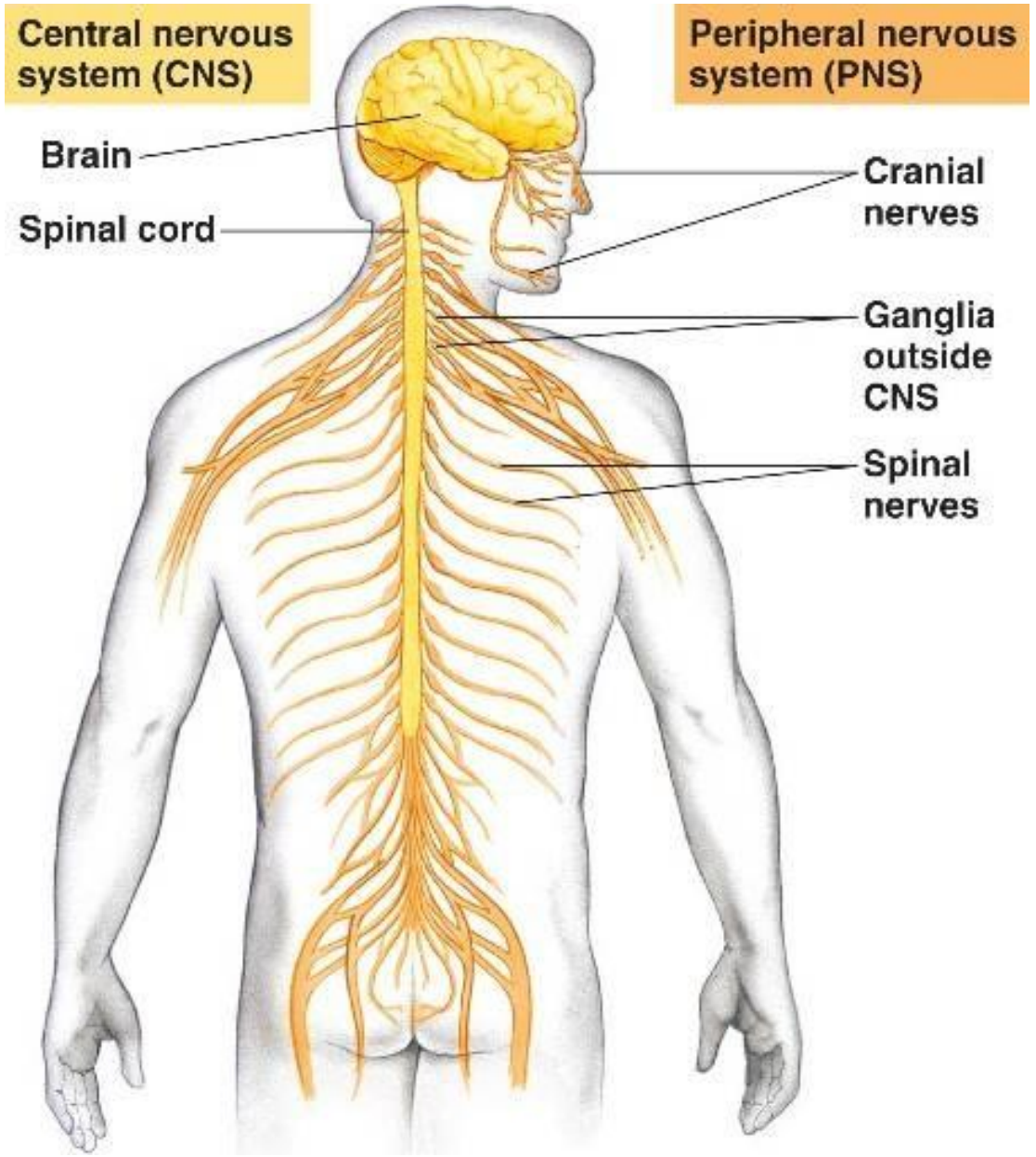
consists of **a dorsal brain and a ventral, ganglionated longitudinal nerve cord** (primitively paired) from which lateral nerves extend in each segment.

Nervous system of the arthropod (grasshopper)

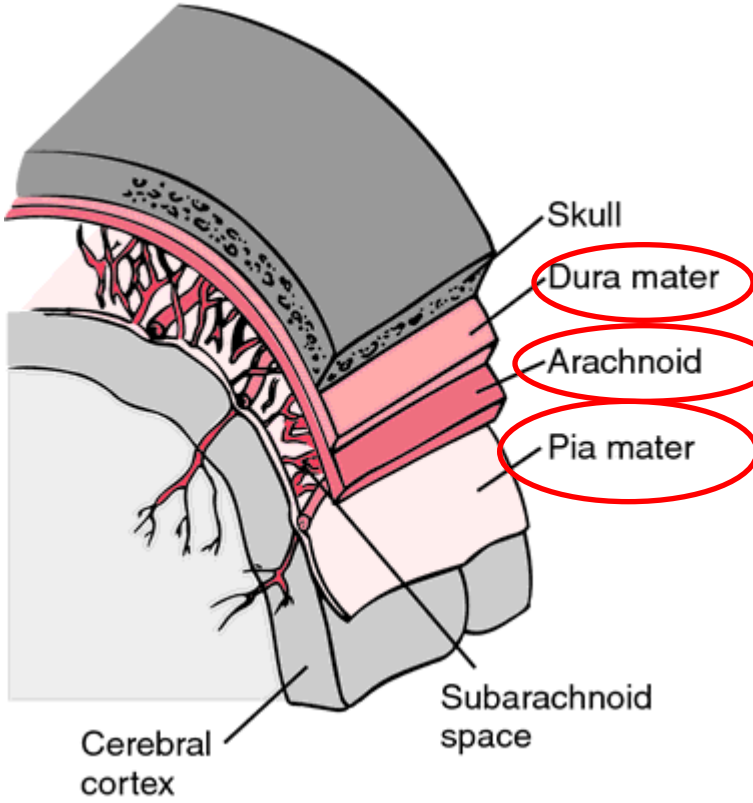


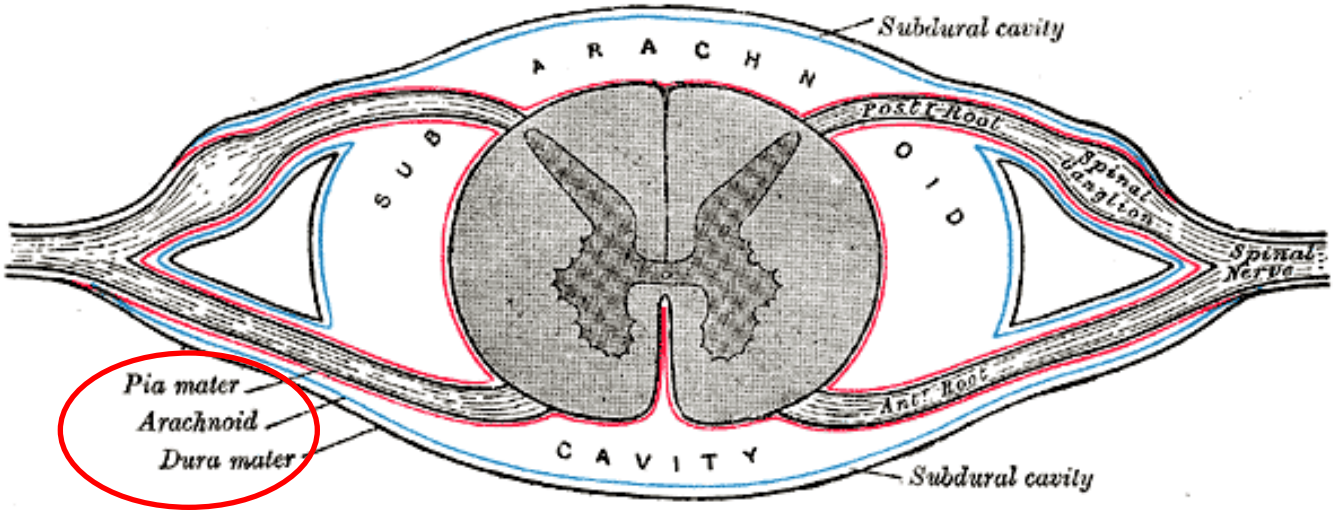
VERTEBRATA (Chordata)

- nerve system dorsally



- Central nervous system protected with meninges

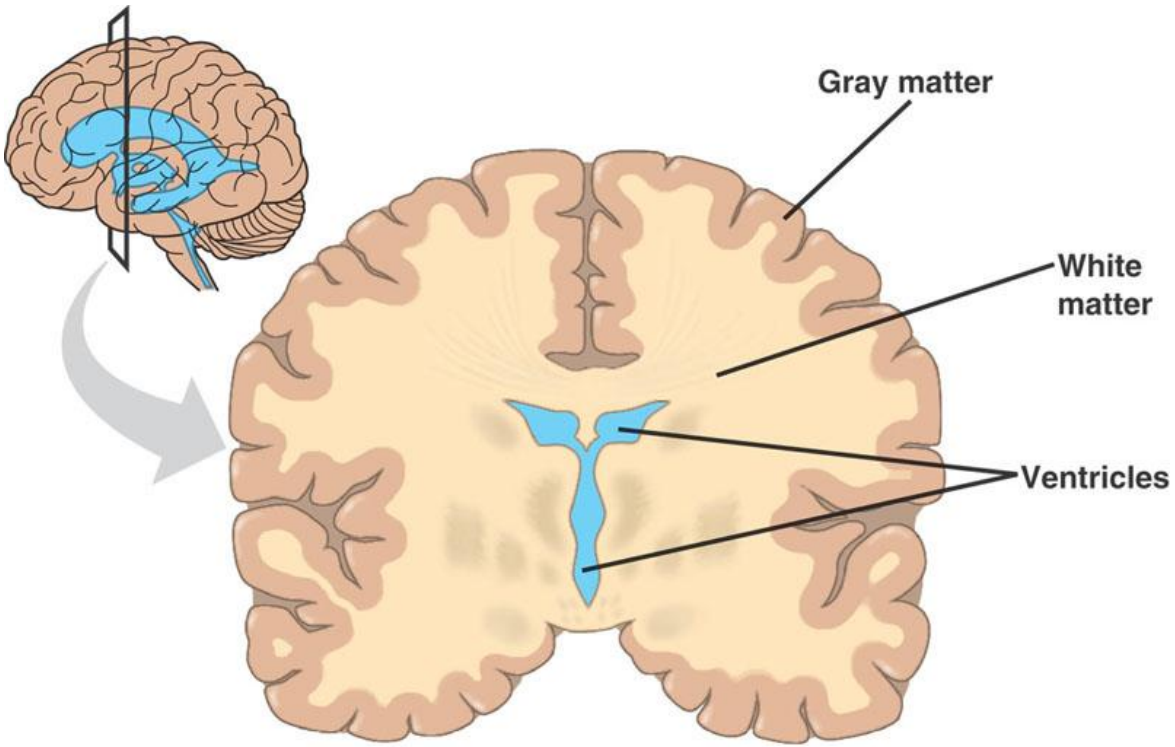




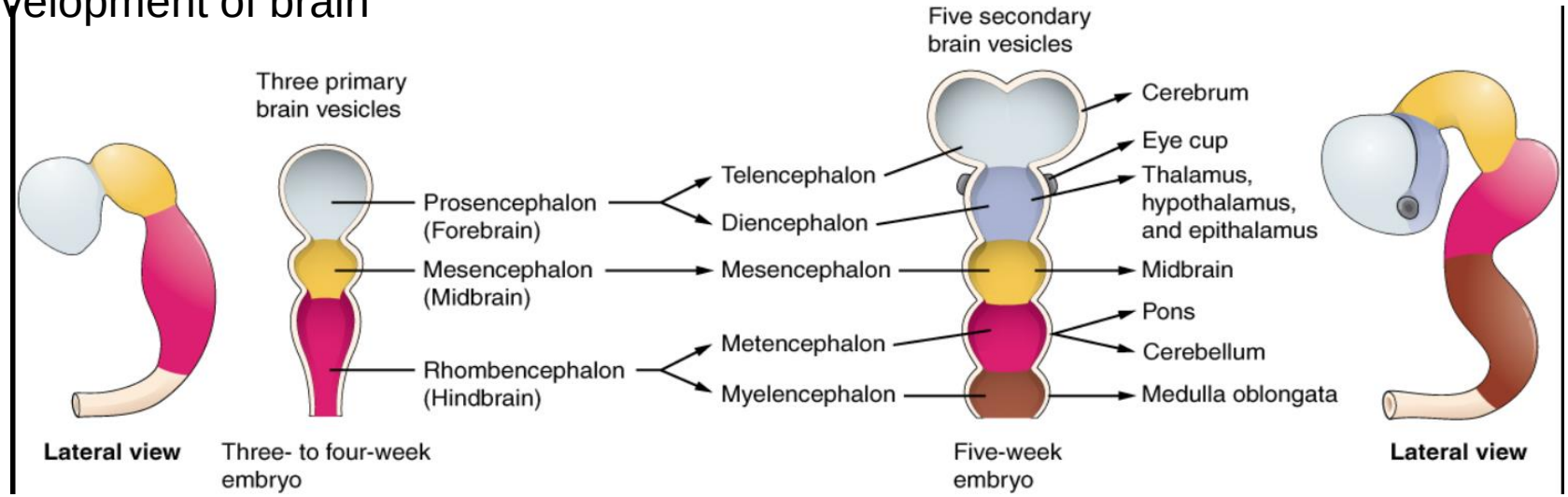
Brain

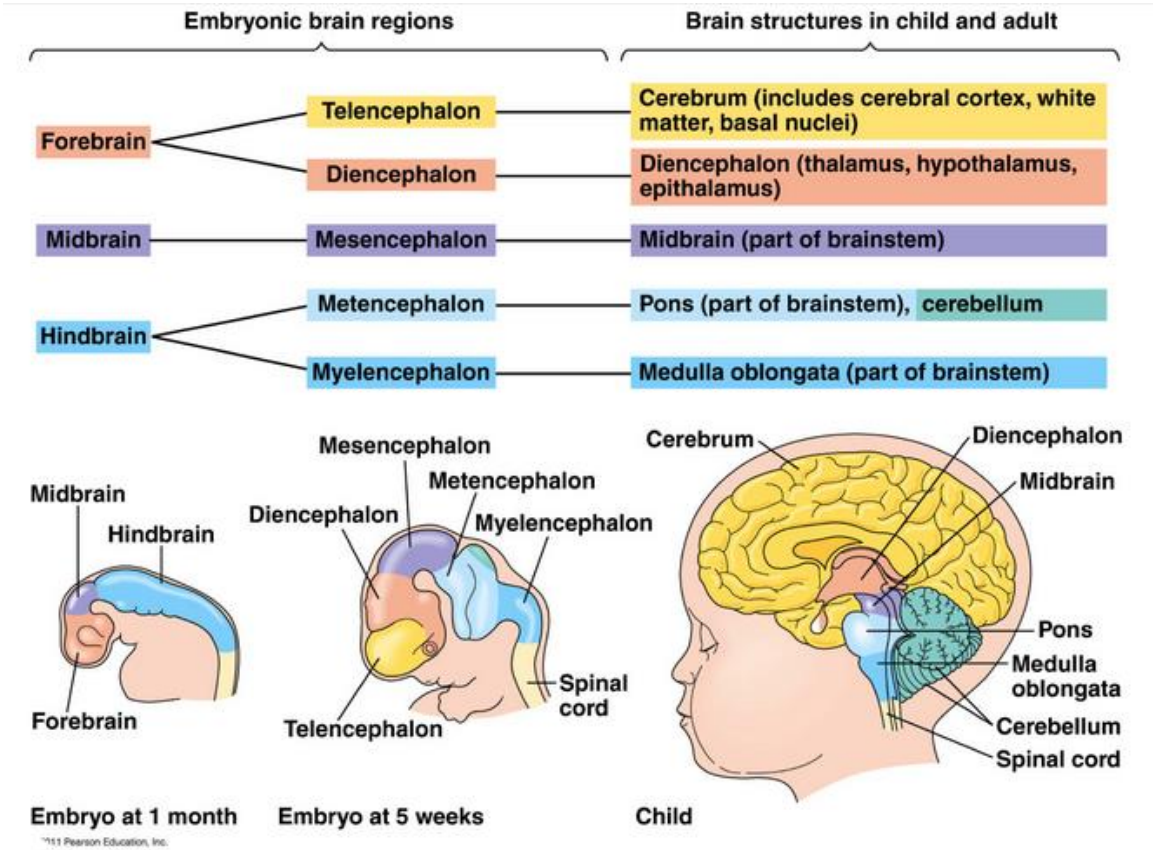
- Surface – gray matter = nerve cells with dendrites
- Middle – white matter – axons

- Rugosity of brain surface indicates that evolution of brain was faster than skull growth!



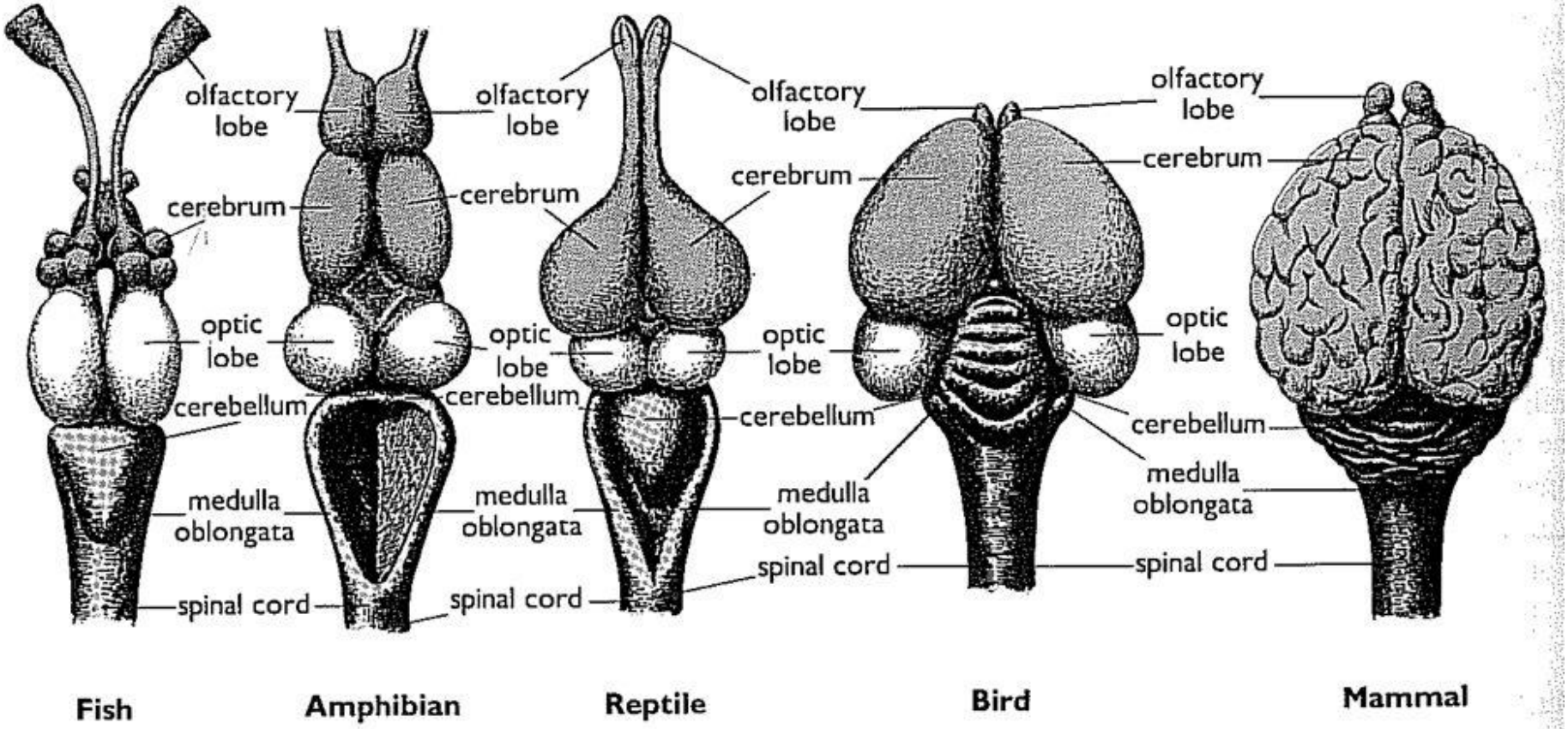
Development of brain



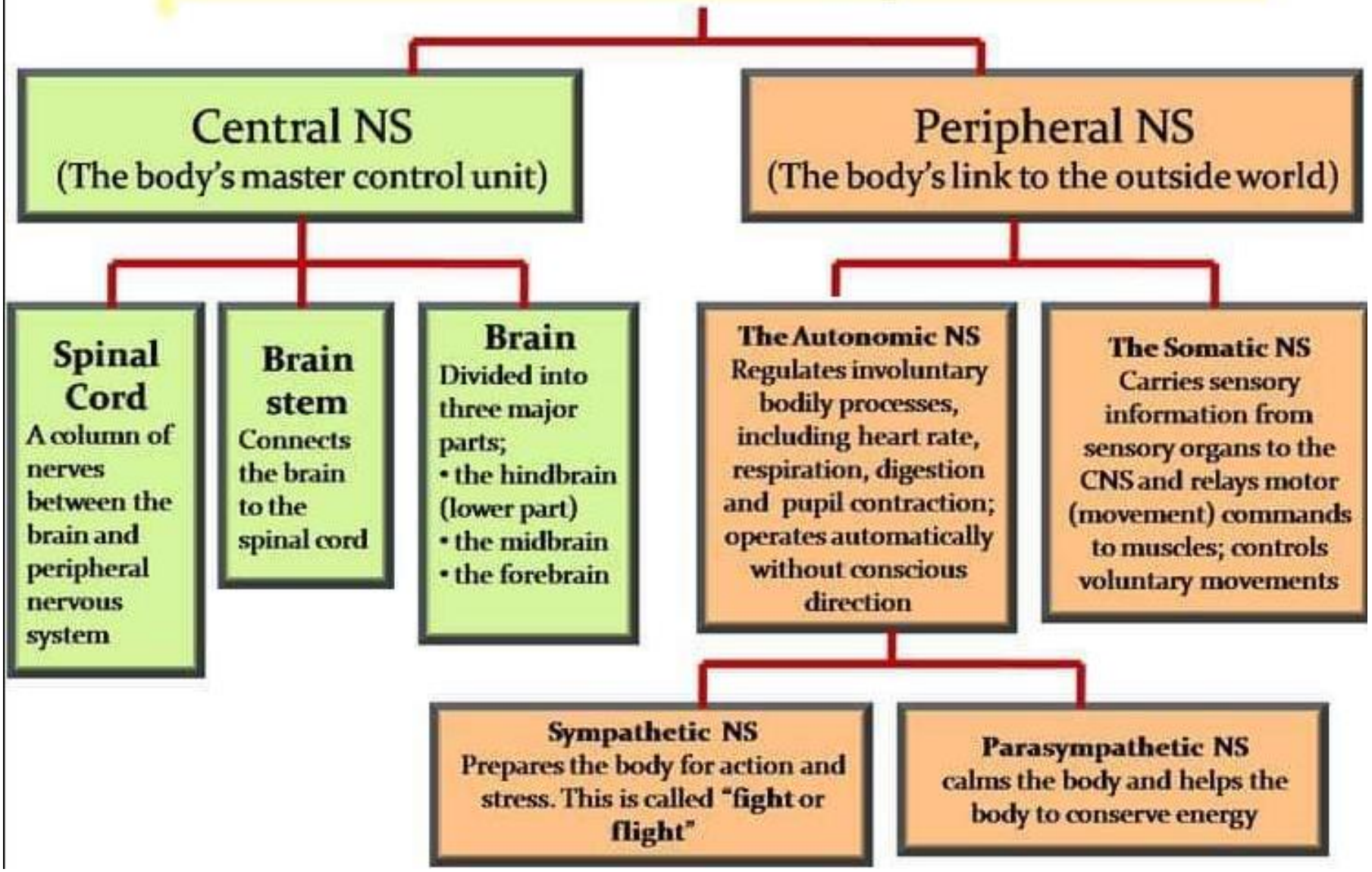


Comparison of Vertebrate Brains

- all vertebrate brains have the same basic parts, but their relative sizes vary



The Nervous System



sensory system

ROLE

The main function of the sensory nervous system is to **inform the central nervous system about stimuli affecting us from the outside or within u**s. By doing so, it informs us about any changes in the internal and external environment. It includes :

- Organelles
- Cells
- Tissues
- Organs

Exteroceptors

A sensory receptor that responds to stimuli from outside the body.
Include touch, pressure, pain, and skin-temperature receptors, as well as special receptors in the eye and ear concerned with sight and hearing

Proprioceptors

sensory receptors located in the subcutaneous tissues. They are capable of detecting motion (or movement), blood pressure, % oxygen in the blood, hunger…

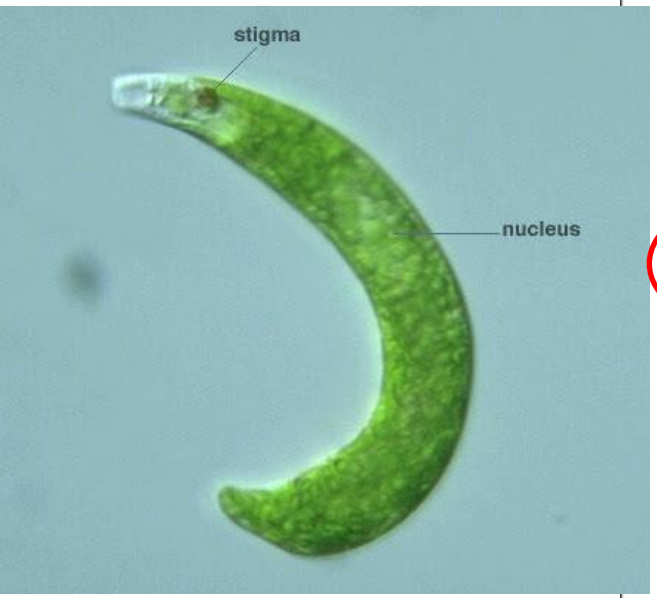
Classification of sensory Receptors

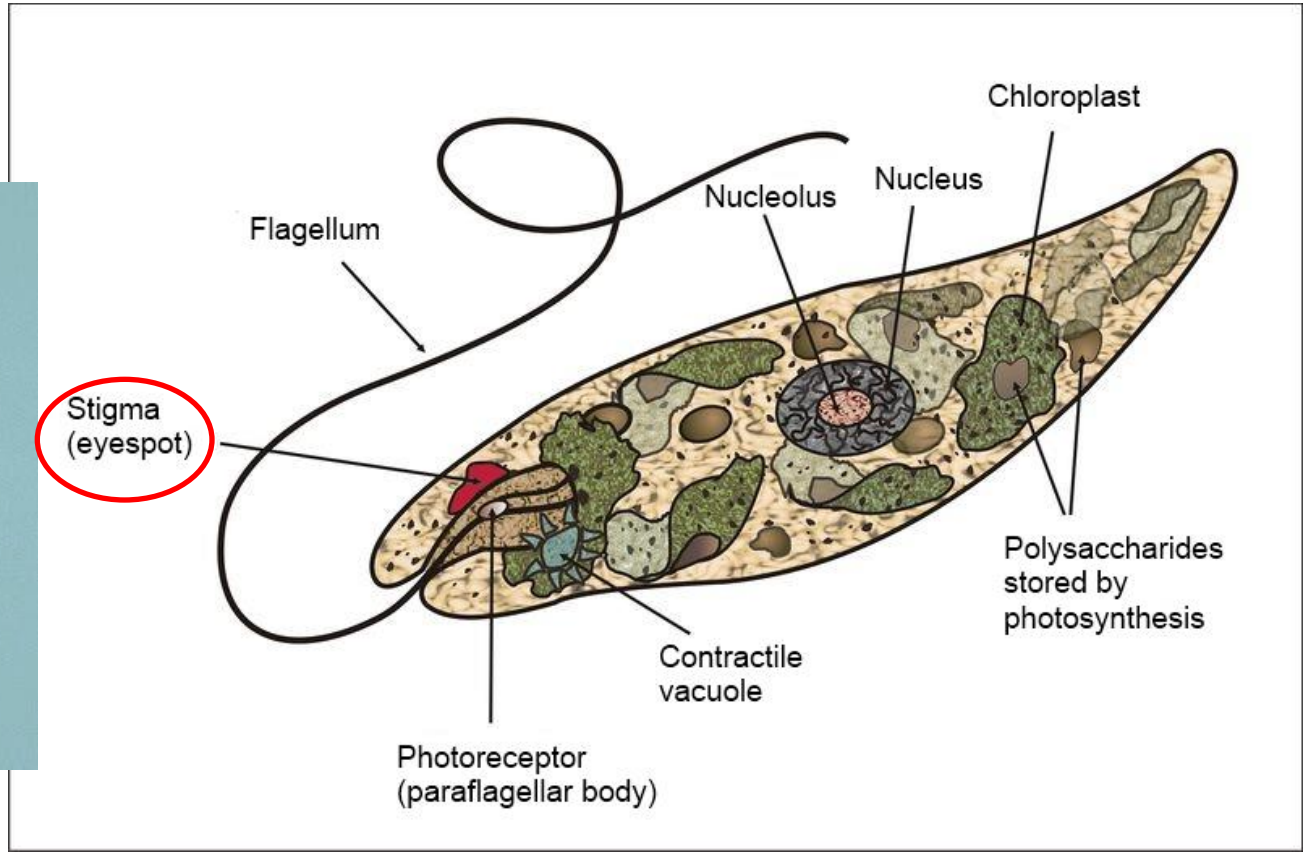
S.No	Receptor Types	Receptors
1.	Mechanoreceptor	Skin Tactile sensibilities, Deep tissue sensibilities, Hearing, Equilibrium, Arterial Pressure.
2.	Thermoreceptor	Warm and cold
3.	Nociceptor	Pain
4.	Electromagnetic receptors	Vision
5.	Chemoreceptors	Taste, Smell, Arterial Oxygen

PROTISTS

- No special organelle – the whole body reacts
- Some Cilliata – organelles for mechanical or chemical stimuli

- Some Flagellate (Euglena)
- Eyespot (stigma) - Eyespot-mediated light perception helps the cells in finding an environment with optimal light conditions for photosynthesis





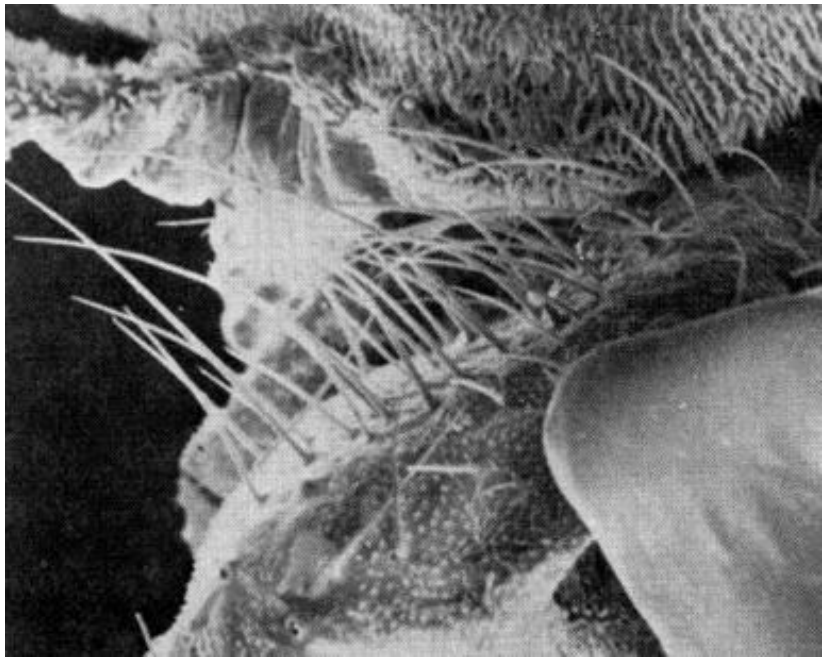
MECHANORECEPTORS

TACTILE

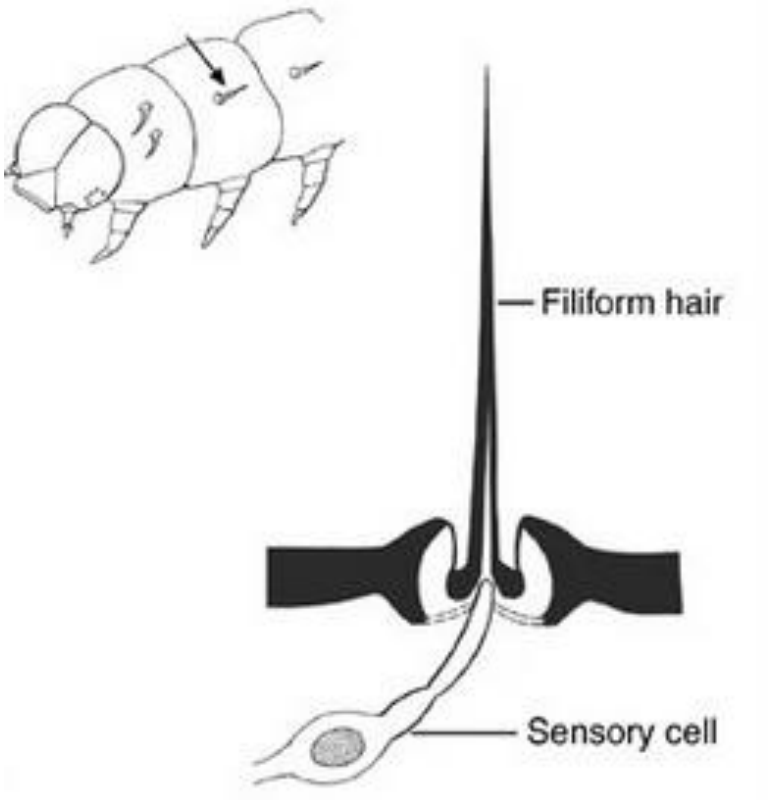
- pressure, strike, deformations, vibrations….
- Sensory cells all around body (more on extremities – tentacles, fingers…)

INVERTEBRATES

- Normally with hairs (hair transfer movement to sensory cell)

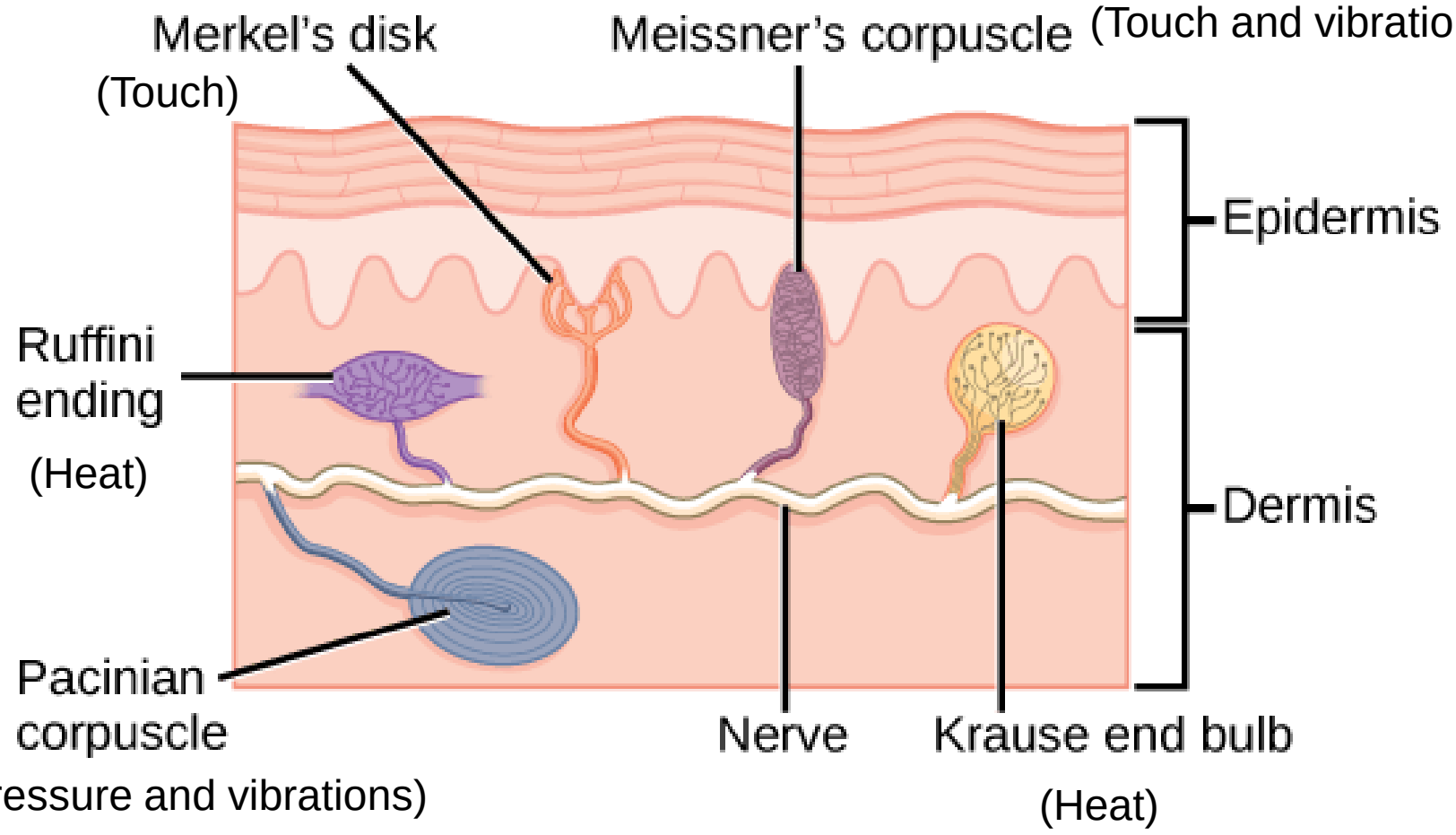


Hairs on cockroach



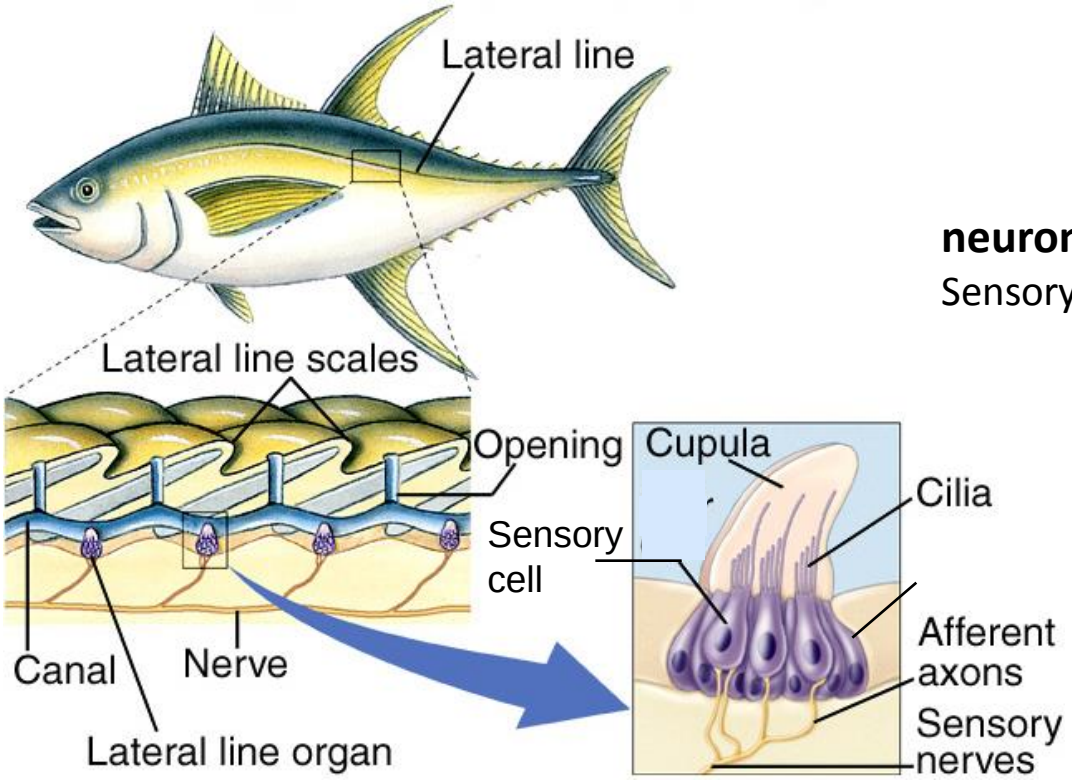
VERTEBRATES:

- Free nerve endings
- Sensory „bodies”



Lateral line – fish and amphibians (direction and strength of the water flow)

Rheoreceptor – feel the water flow



neuromasts

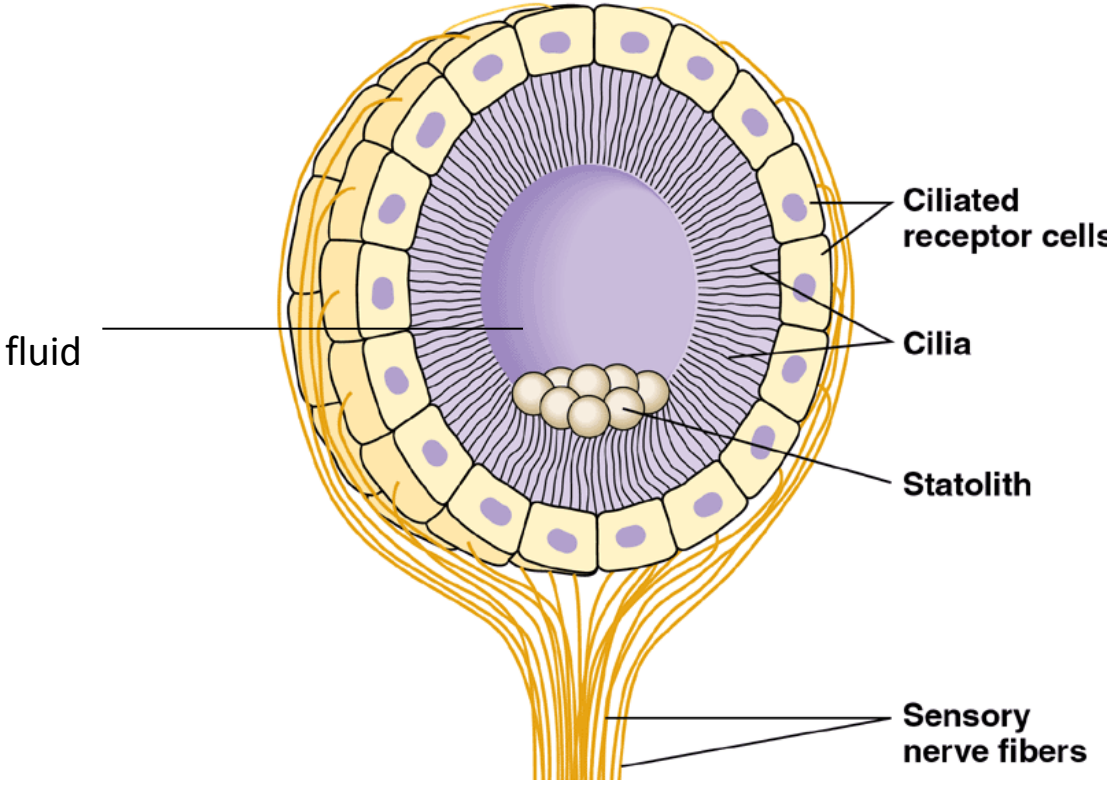
Sensory cells with cilia in the gel cupula

STATIC AND SOUND (HEARING)

► **static** **role** – register posture of the body in the space (toward gravity) (= georeceptors)

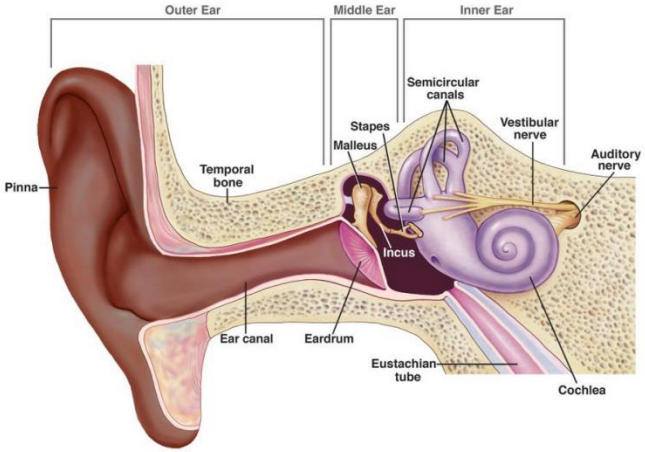
- Similar building plan in all animals

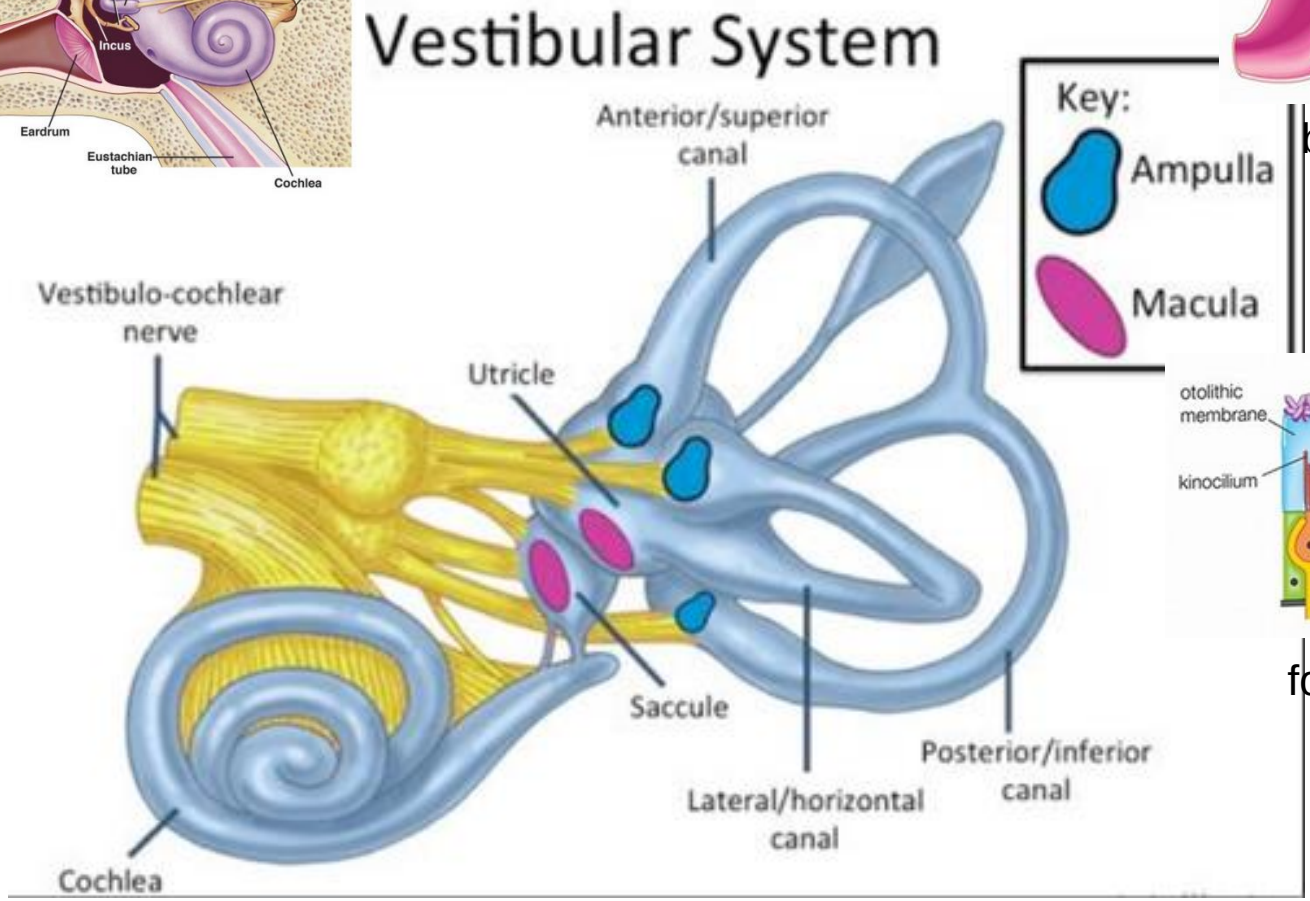
- **Invertebrates** - statocists – epidermal bubble with statolithss

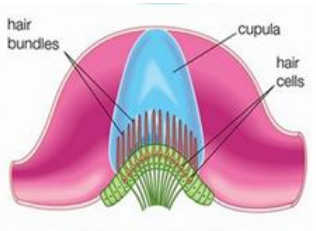


Vertebrates

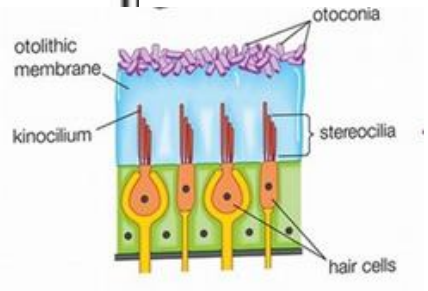
- Vestibular system developed from ectoderm – two parts: <u>utricle</u> (with 3 canals) and <u>saccule</u>



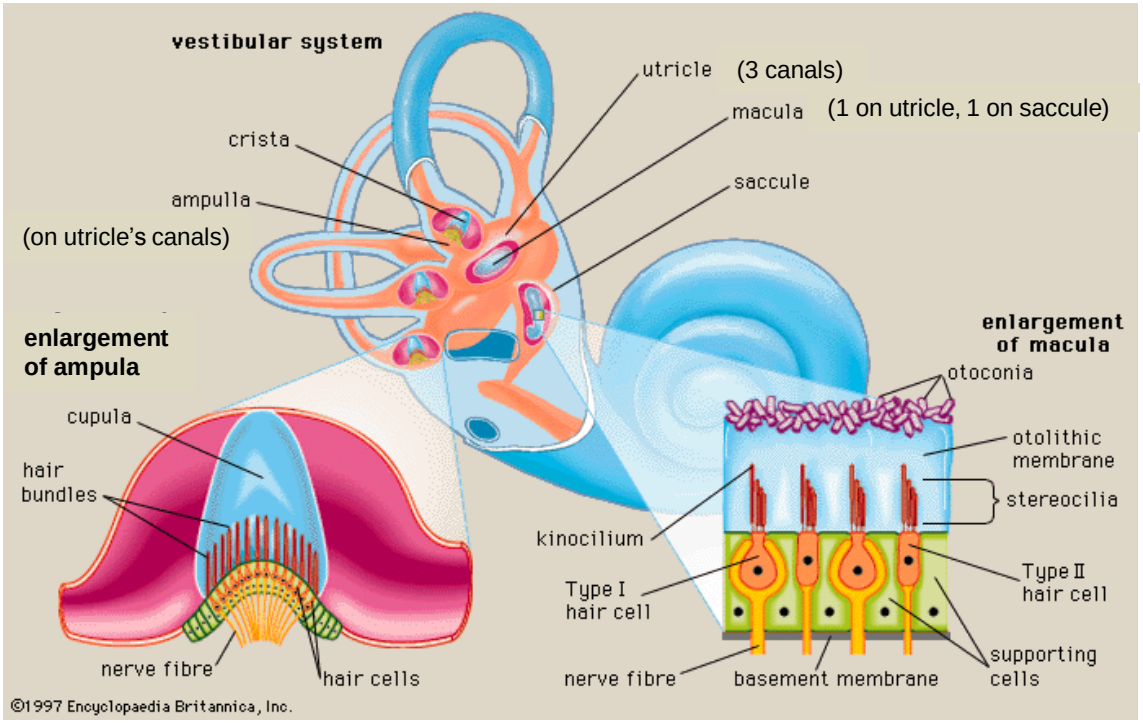




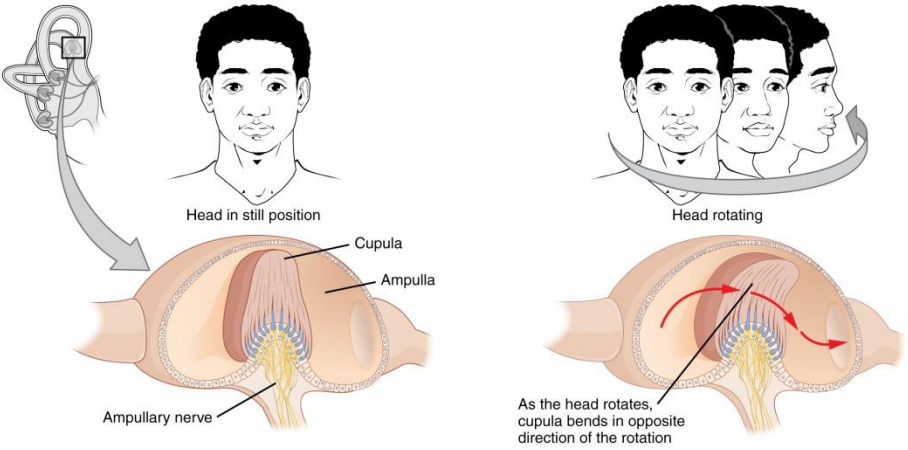
body movement



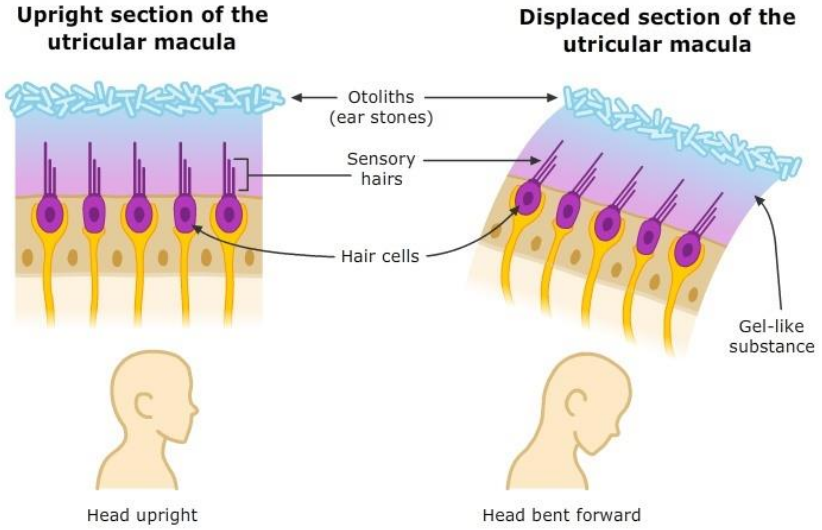
force of gravity



Ampulla – body in movement



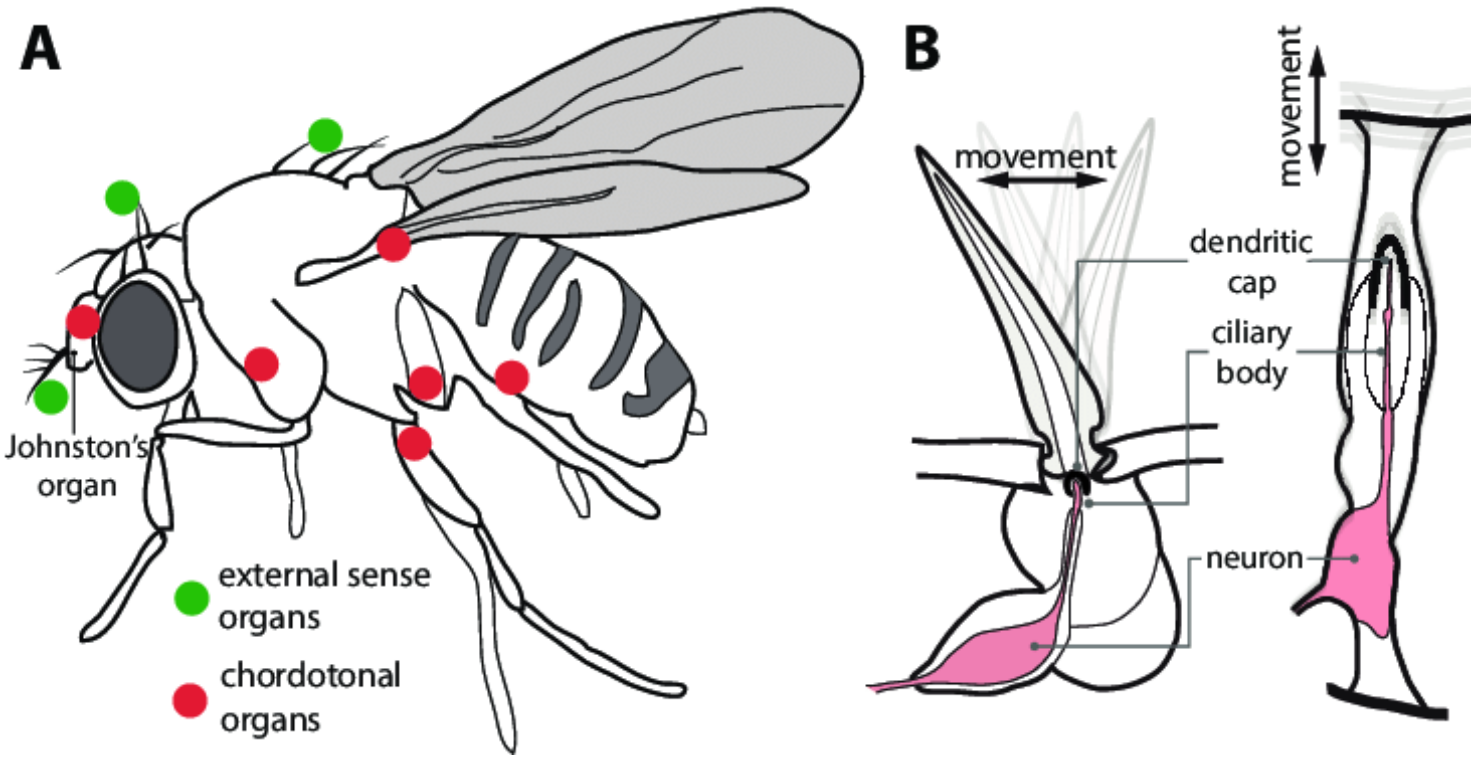
macula – gravity



SOUND - PHONORECEPTORS

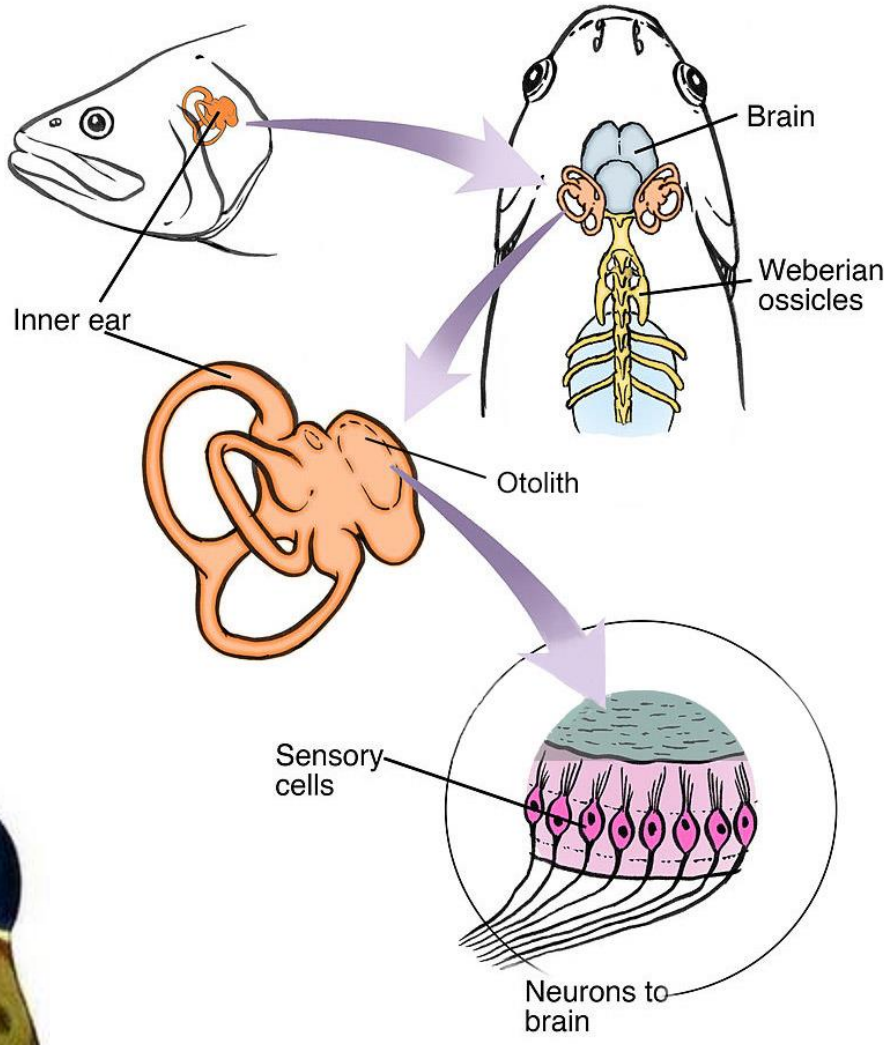
- Insects and vertebrates (animals that produce sound)

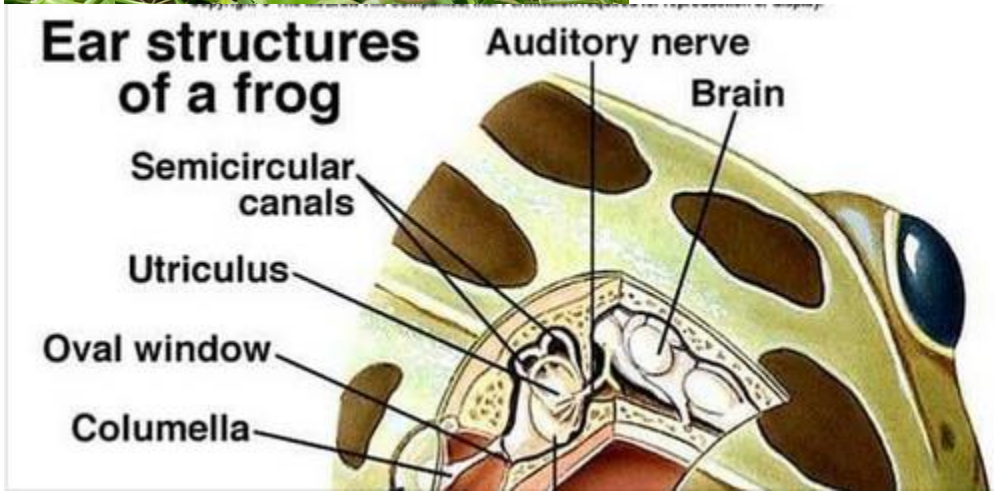
INSECTS - chordotonal organs



VERTEBRATES

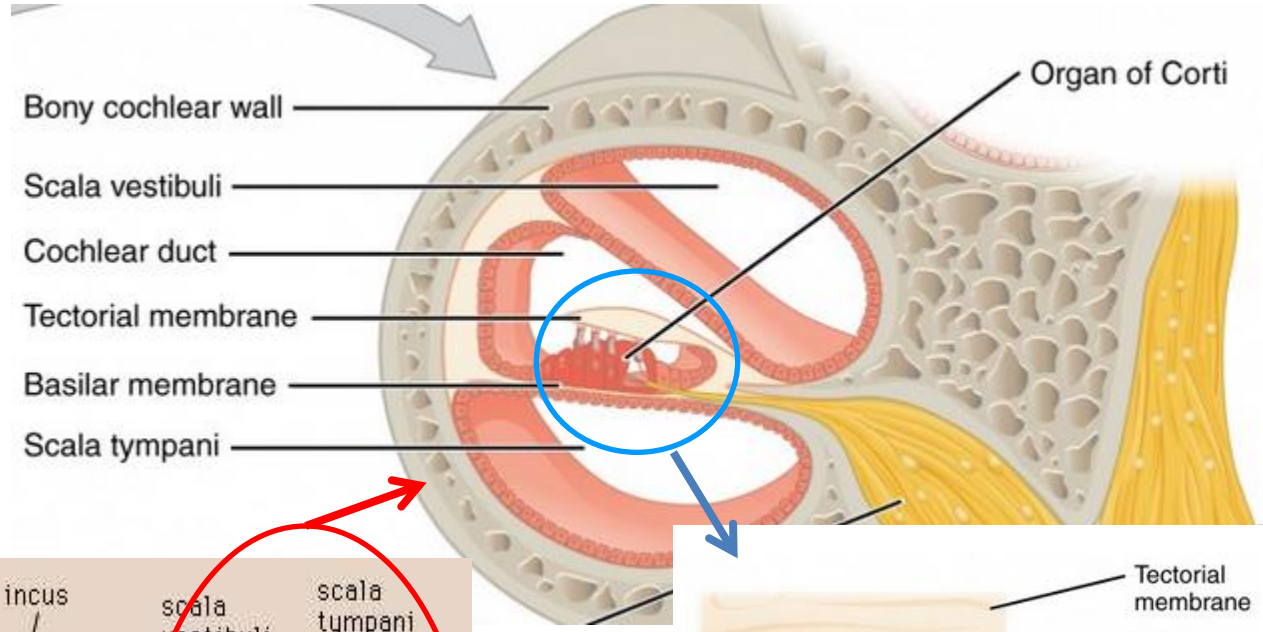
Fish only inner ear

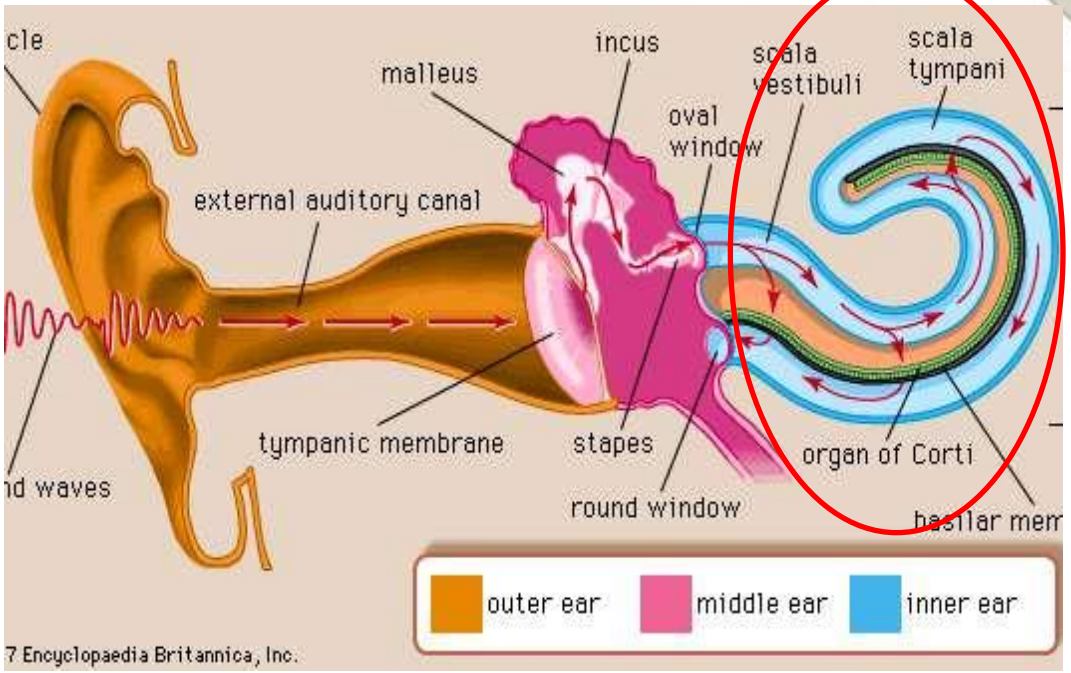


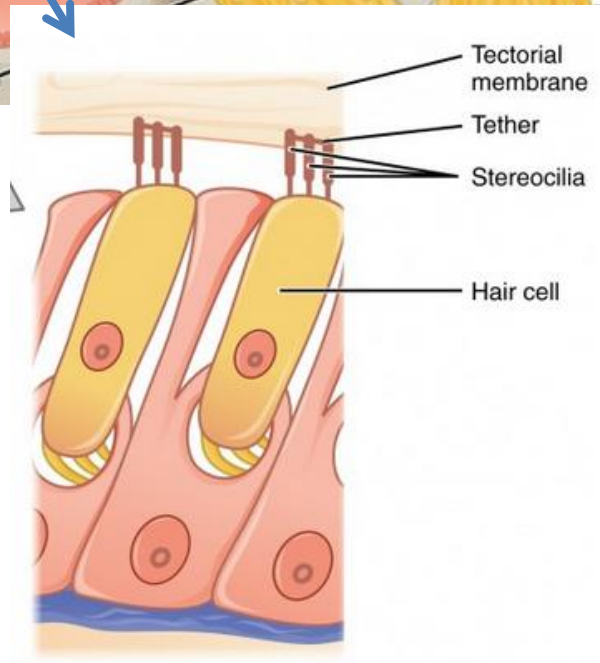


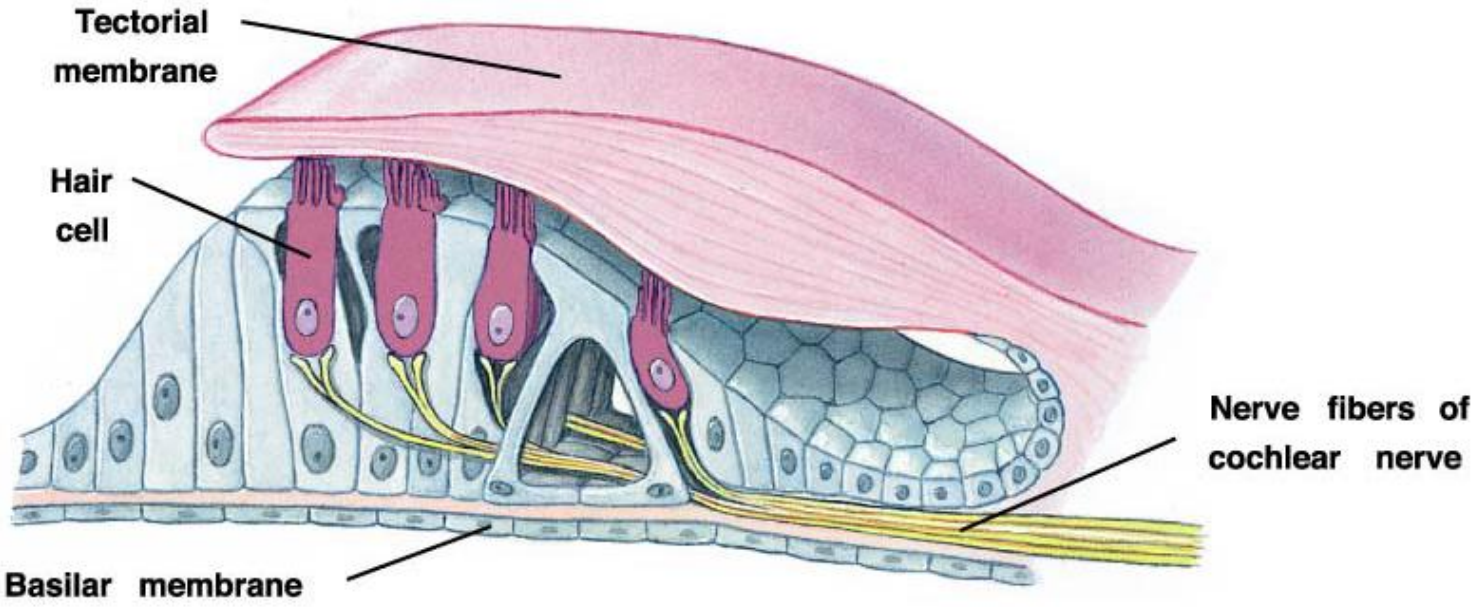
Amphibians and **Reptiles** middle and inner ear

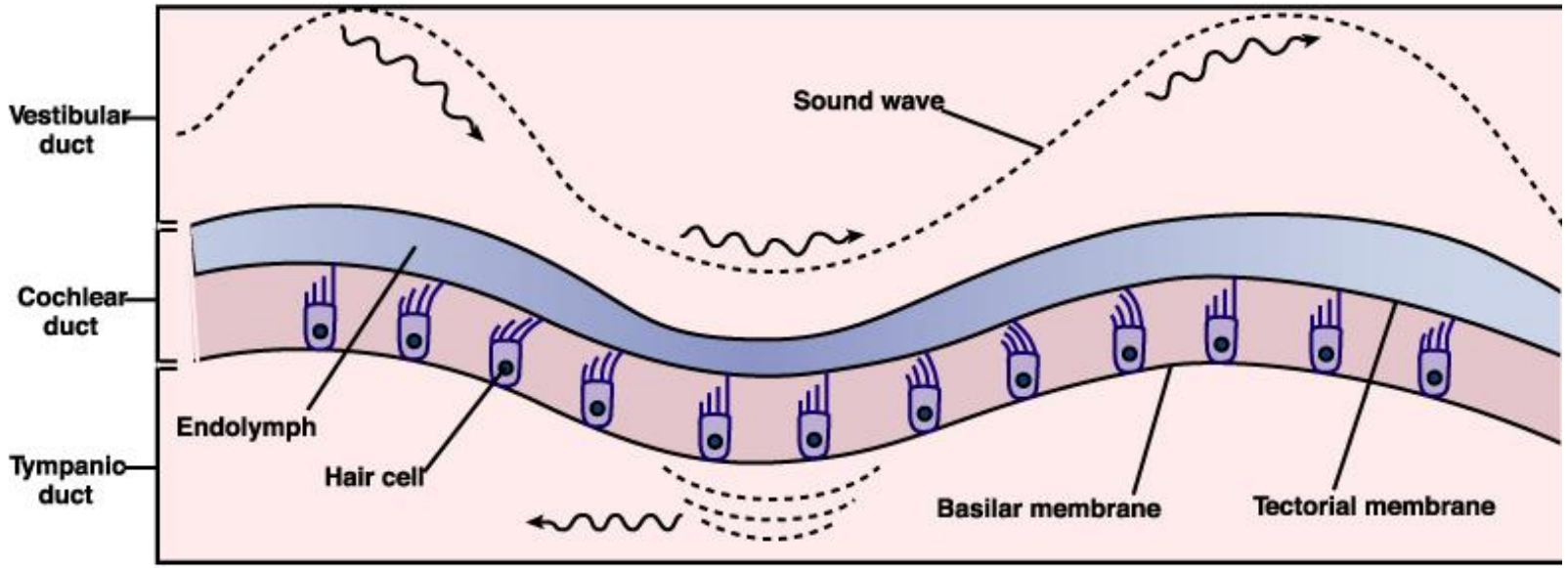
Birds and **Mammals** outer, middle and inner ear + connection to pharynx








Tectorial membrane
Hair cell
Nerve fibers of cochlear nerve
Basilar membrane

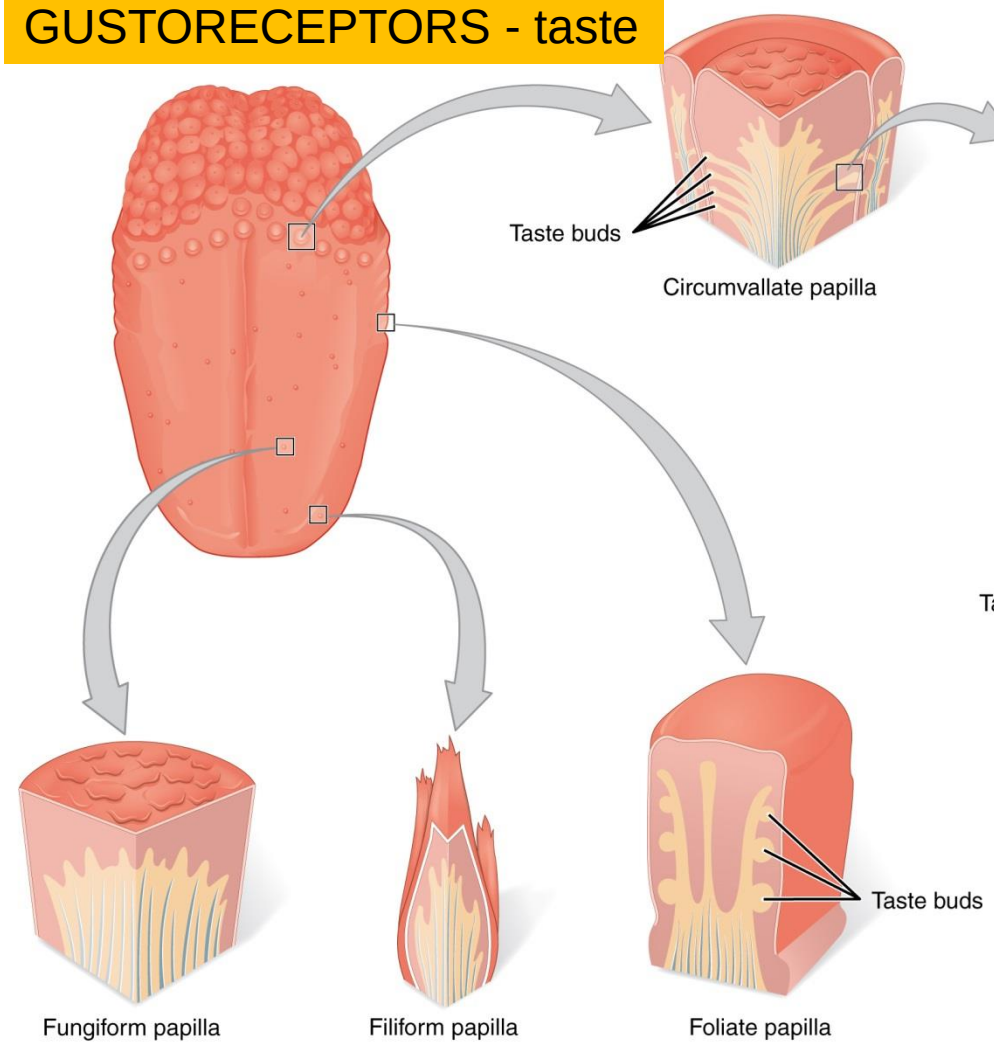

Vestibular duct
Cochlear duct
Tympanic duct
Sound wave
Endolymph
Hair cell
Basilar membrane
Tectorial membrane

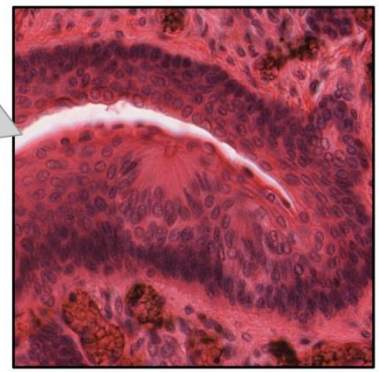
CHEMORECEPTORS

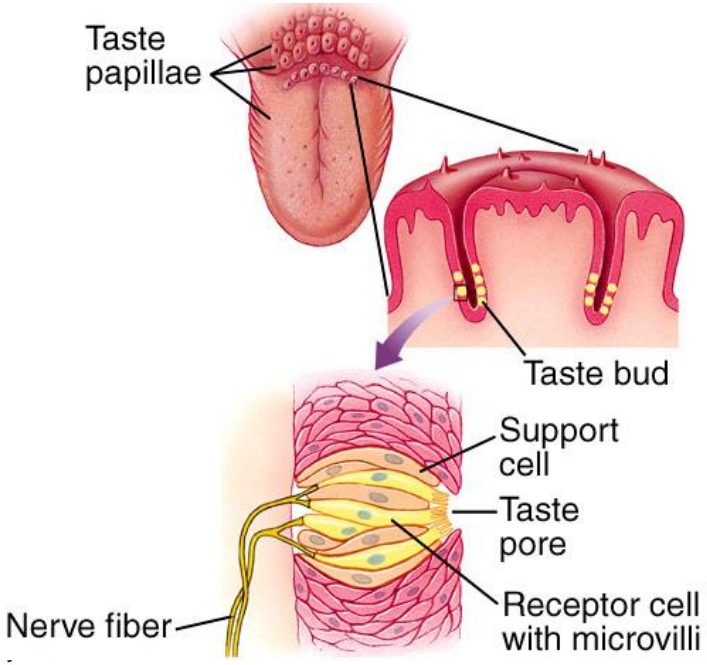
► smell and taste

- In terrestrial animals in special organs, in aquatic animals all around body

GUSTORECEPTORS - taste

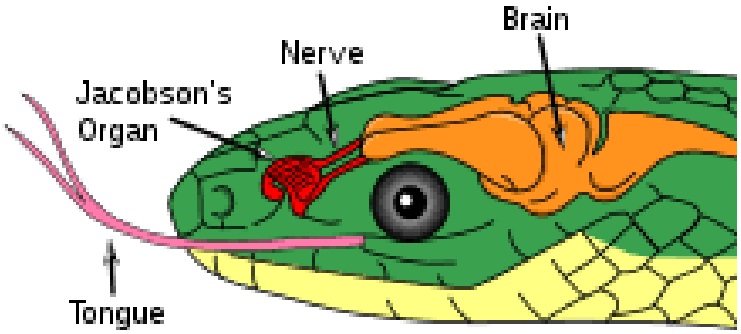






STIBORECEPTORS - smell

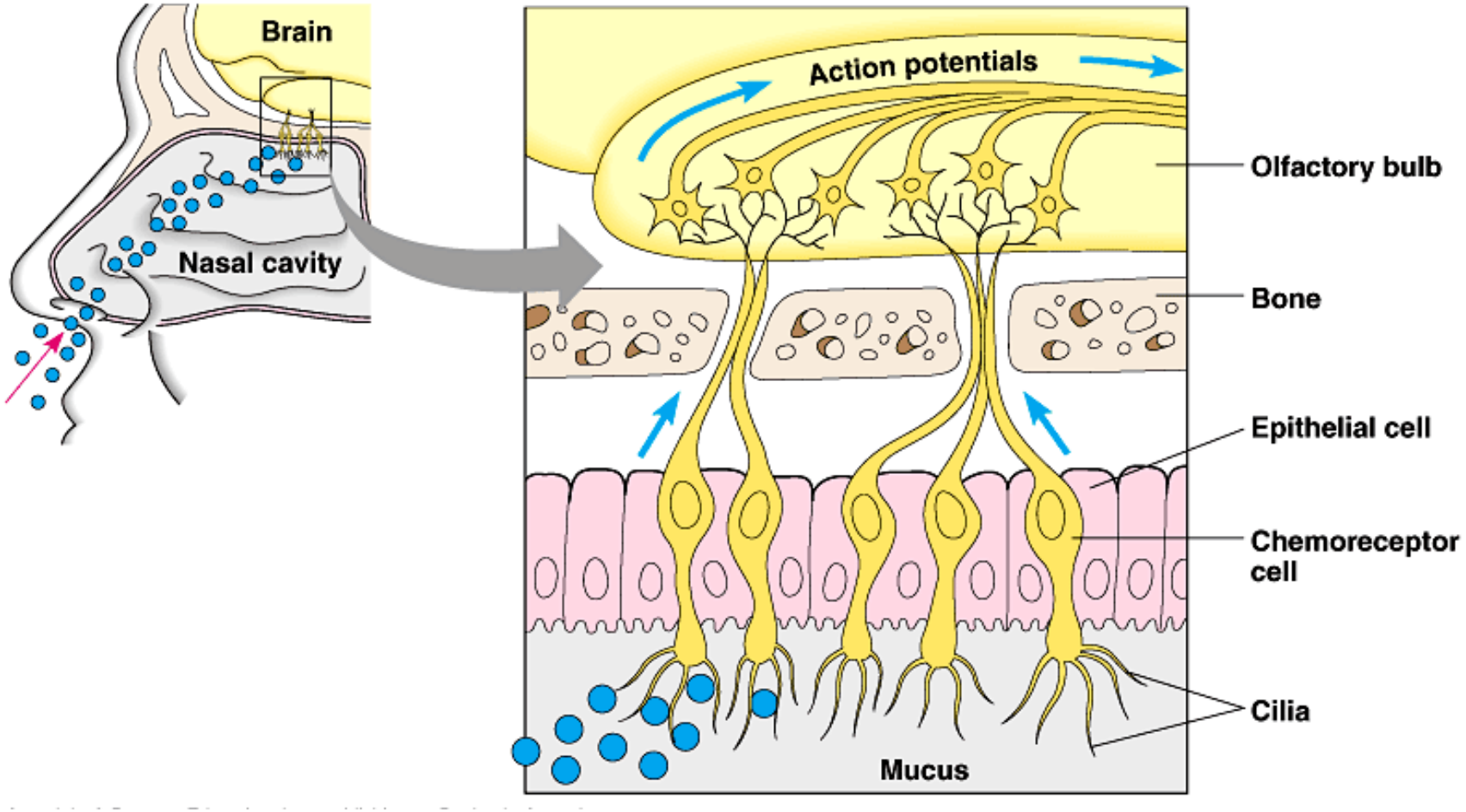
Vertebrates – most frequent in the nasal cavity



- **Reptiles** – all but crocodiles have Jackobson's organ – tongue brings chemical particles

- **Birds** – not well developed (except vulture birds)

- **Mammals**


Brain
Nasal cavity
Action potentials
Olfactory bulb
Bone
Epithelial cell
Chemoreceptor cell
Cilia
Mucus

PHOTORECEPTORS

- Light cause reaction

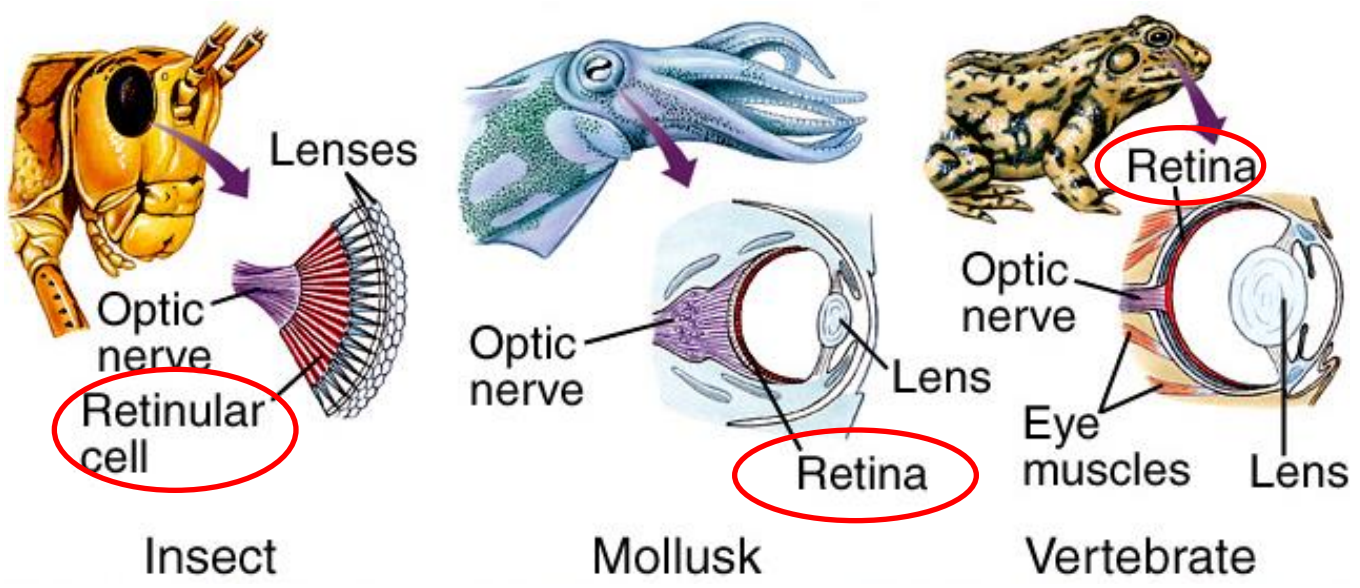
- Always connected to eyes

► always includes :

- **sensory cells**
- **pigment cells**

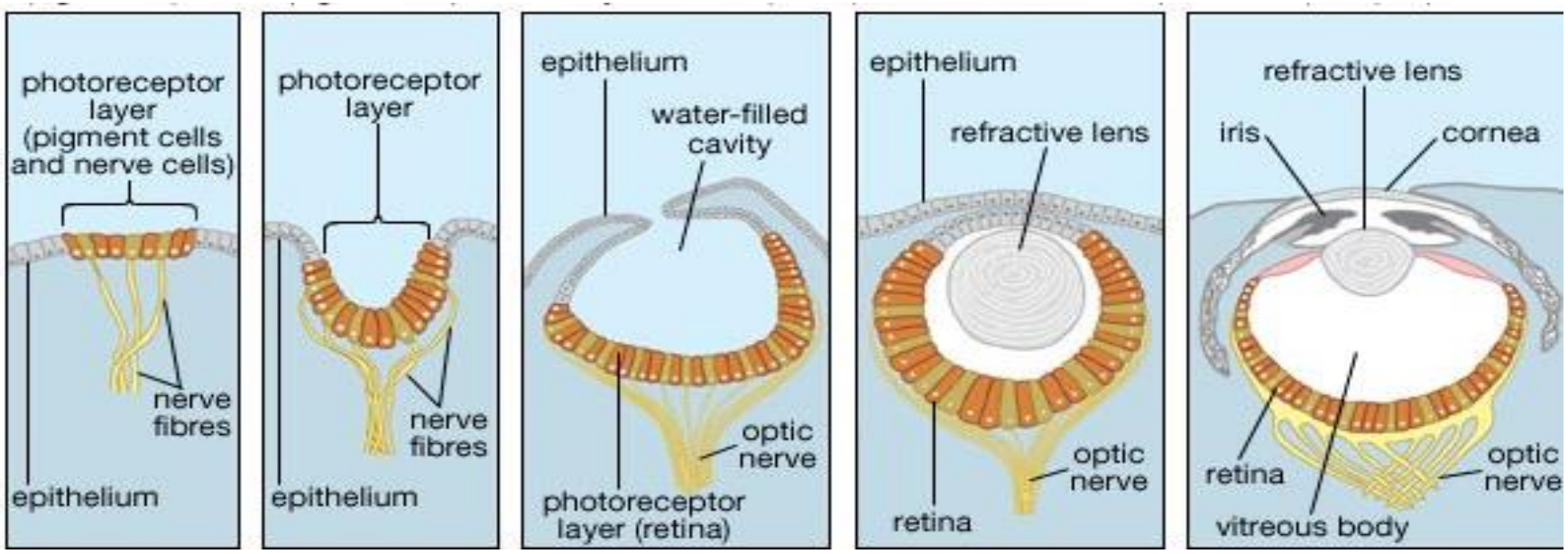
} **retina**

- Additional parts help making picture more clear

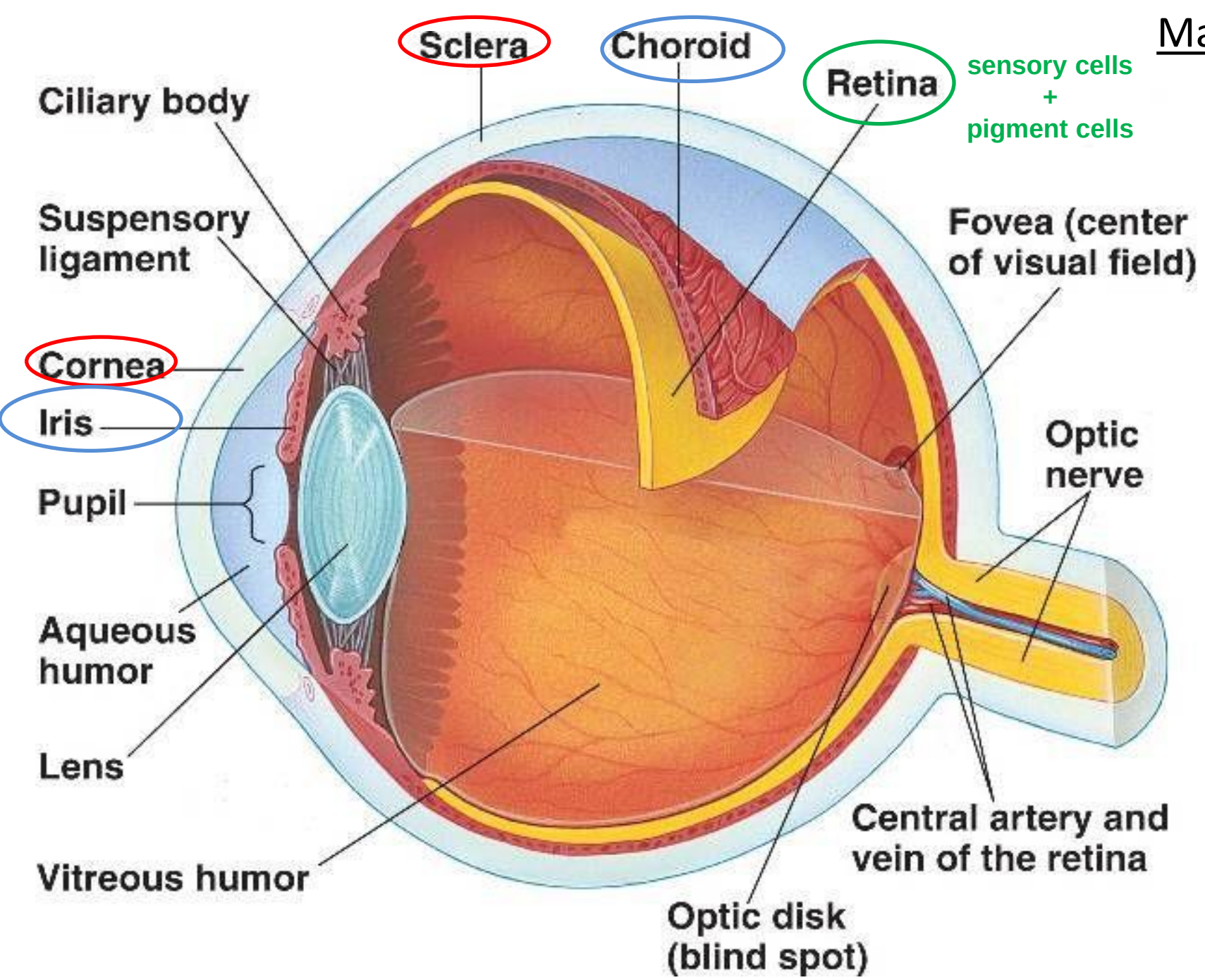


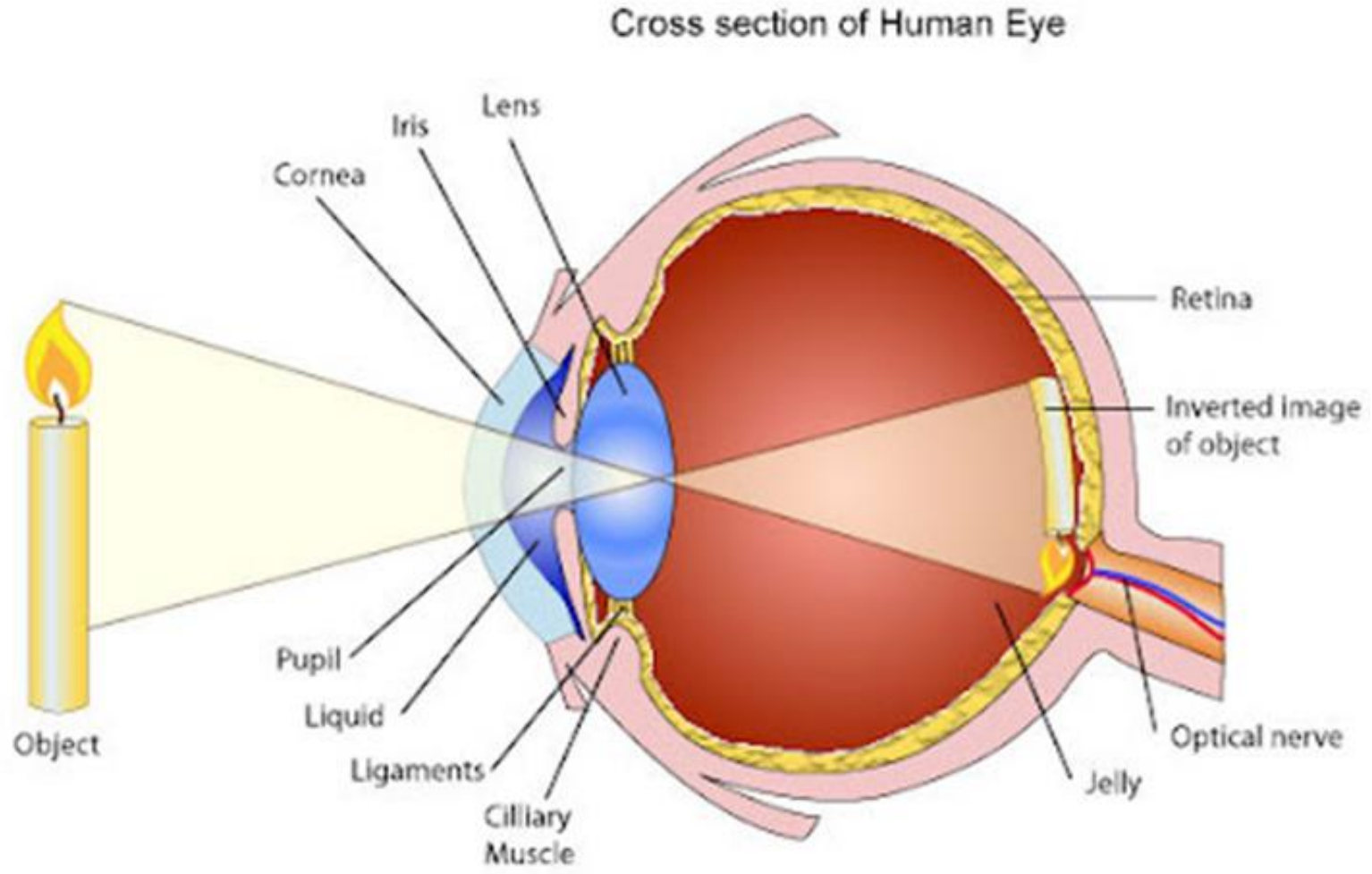
- INVERTEBRATES – eye develops from epidermis (sinking)
- VERTEBRATES – eye develop from frontal part of brain (bulging) – invers eye

Evolution of the eye

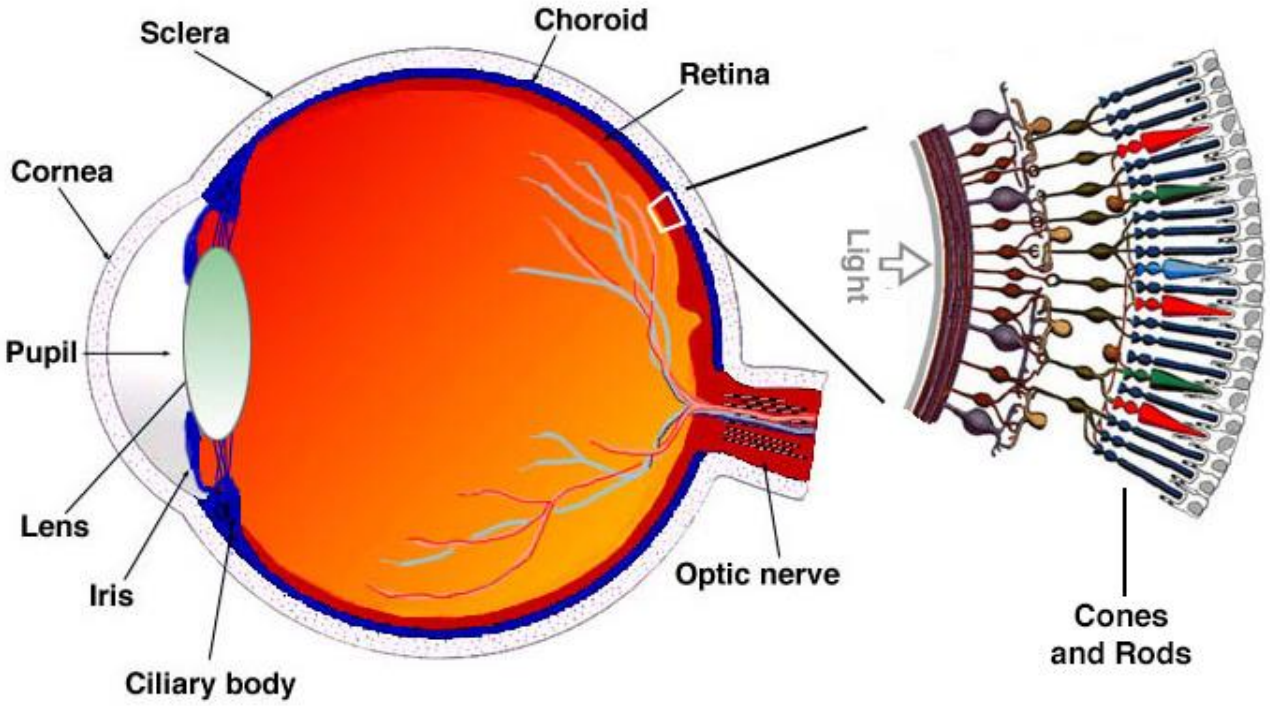


Mammals


Sclera
Choroid
Retina
sensory cells
+
pigment cells
Ciliary body
Suspensory ligament
Fovea (center of visual field)
Cornea
Iris
Pupil
Optic nerve
Aqueous humor
Lens
Vitreous humor
Central artery and vein of the retina
Optic disk (blind spot)

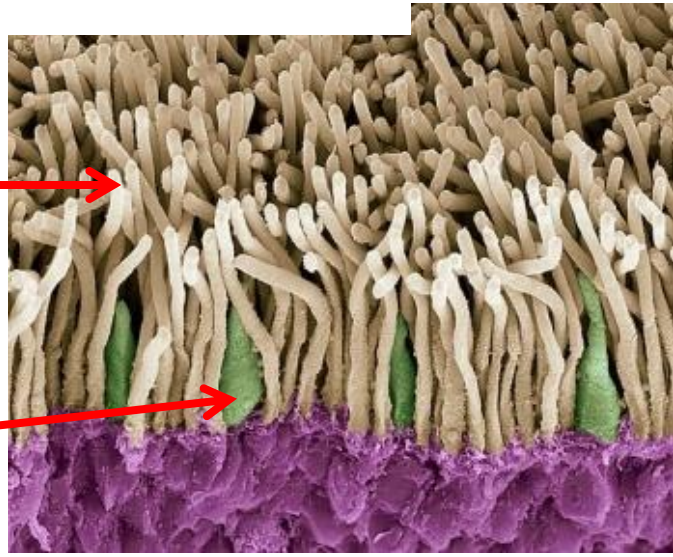


An image is formed on the retina with light rays converging most at the cornea and upon entering and exiting the lens.
Rays from the top and bottom of the object are traced and produce an inverted real image on the retina.

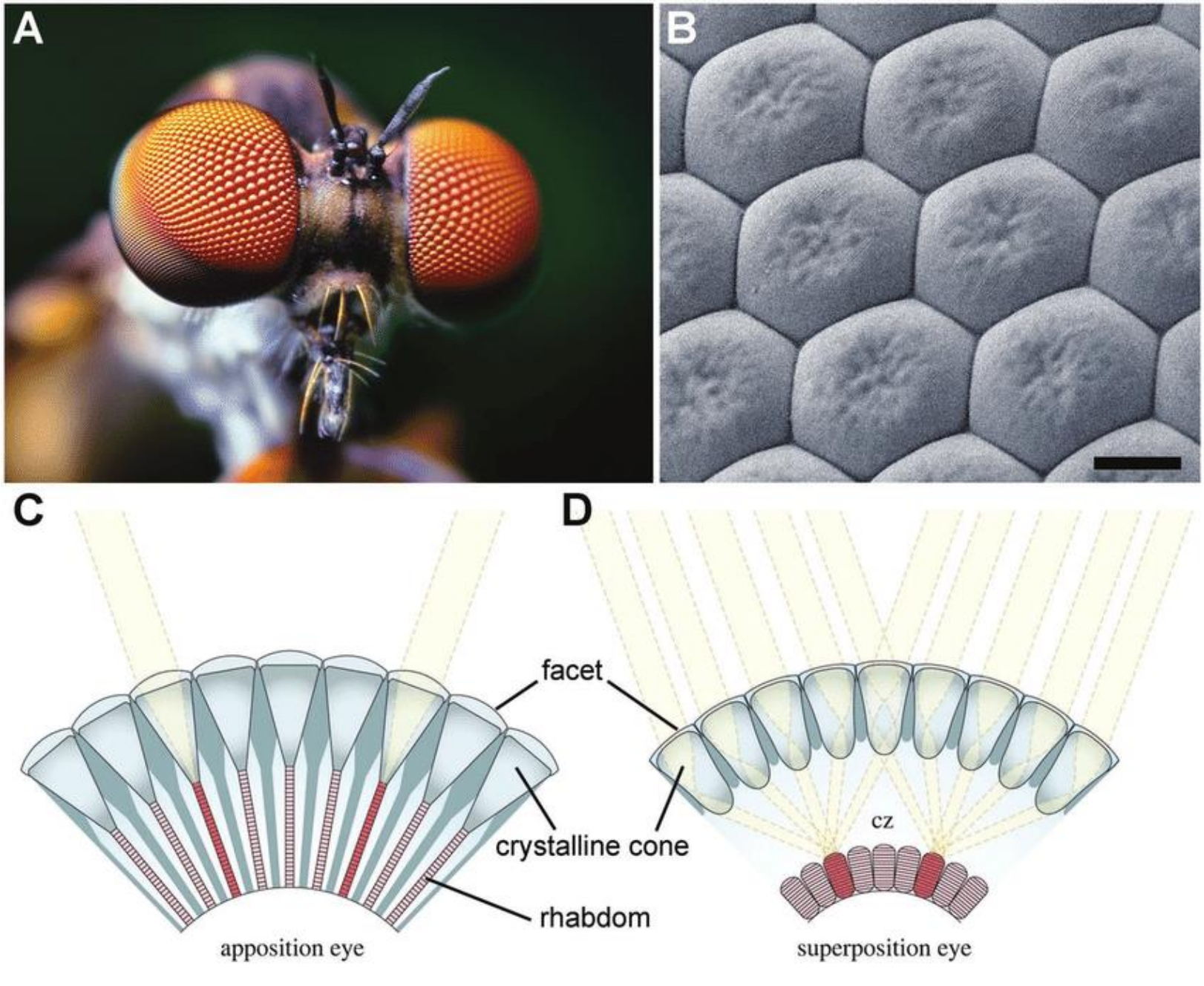


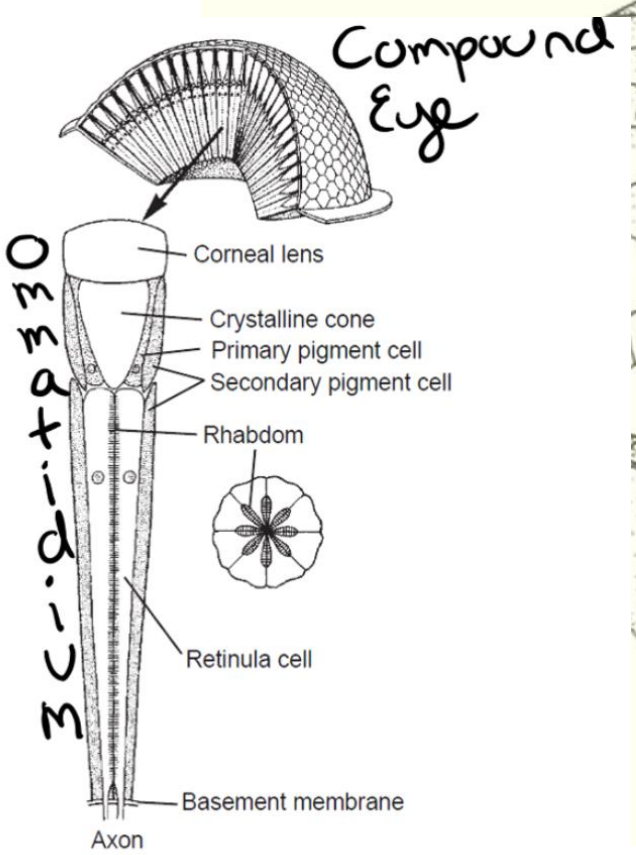
Rods – black-white

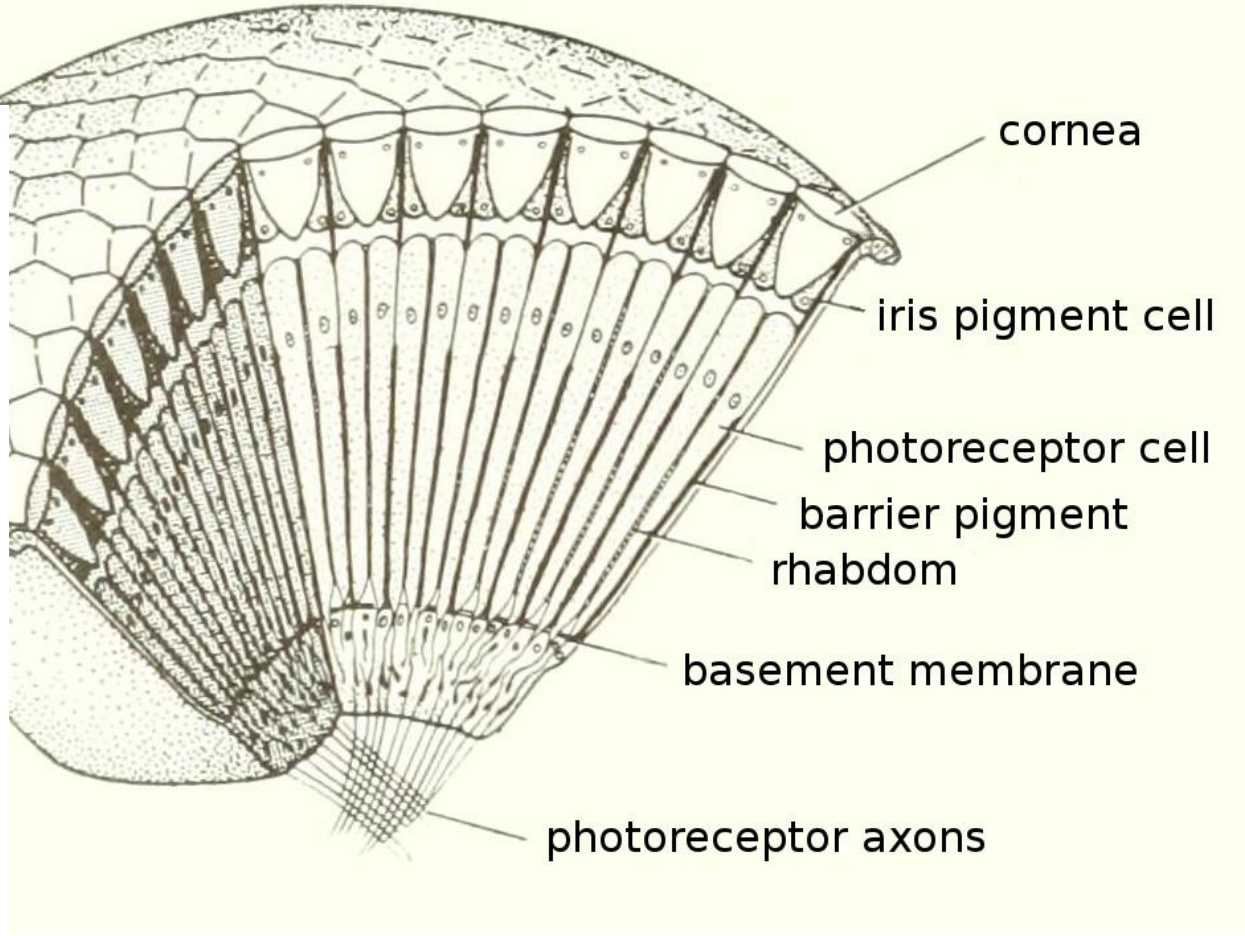
Cones – colour



COMPOUND EYES OF INSECTS







In rhabdom – microvilli that react onto light stimuli and send impulse