SEM – IV

CC – 8: COMPARATIVE ANATOMY OF VERTEBRATES

C8T: Unit 8: SENSE ORGANS

Prepared by Anindita Das

Classification of Receptors

Classification of receptors by Stimulus:

Sensory receptors are primarily classified by the type of stimulus that generates a response in the receptor. Broadly sensory receptors respond to one of the four primary stimuli:

1. Chemicals - chemoreceptors
2. Temperature - thermoreceptors
3. Pressure - mechanoreceptors
4. Light – photoreceptors

All sensory receptors rely on one of these four capacities to detect the changes in the environment, but may be tuned to detect specific characteristics of each to perform a specific sensory function.

These receptors perform countless functions in our body. During vision, rod & cone photoreceptors respond to light intensity and color. During hearing, mechanoreceptors in hair cells of the inner ear detect vibrations conducted from the eardrum. During taste, sensory neurons in our taste buds detect chemical qualities of our foods including sweetness, bitterness, sourness, saltiness etc. During smell, olfactory receptors recognise molecular features of odors. During touch, mechanoreceptors in the skin and other tissues respond to variations in the pressure.

- **Major receptor types of vertebrates and their functions:**

Types of Receptors		Names	Stimulus
1) Chemical receptors:		Olfactory cells	Smell
		Taste buds	Taste
2) Mechanical, temperature and electrical receptors:	Cutaneous receptors	Free nerve endings	Pain, temperature
		Meissner's corpuscles	Touch & pressure
		Merkel's disks	Touch & pressure
		Pacinian corpuscles	Touch & pressure
		Ruffini endings	Touch & pressure
		Eimer's organs	Touch & pressure
		Sinus hairs	Touch & pressure
	Proprio-receptors	Tendon and joint receptors	Tension
		Muscle spindles	Degree & rate of contraction
	Lateral line, ear & electro-receptors:	Hair cells	Vibration & gravity
		Ampullary organ cells	Electric fields
		Tuberous organ cells	Electric fields
3) Photoreceptors and specialized thermoreceptors:		Rod & cone cells	Visible electromagnetic radiation
		Pit organ cells	Infrared electromagnetic radiation

Classification by encapsulation of nerve endings:

"SIMPLE" RECEPTORS (nerve endings in tissues)

-*Unencapsulated receptors* - free nerve endings (mechanoreceptors, thermoreceptors, nociceptors) – in skin, joints, viscera and oral cavity.

-*Encapsulated receptors* - tissue-associated nerve endings

- Pacinian corpuscles – in deep dermis, hypodermis, viscera, joint capsules.

- Meissner's corpuscles – in dermal papillae near epidermis.

"COMPLEX" RECEPTORS (special senses)

Olfactory, Taste, Labyrinth (equilibrium/balance, hearing), Eye

Olfactory receptors in vertebrate

Olfactory receptors (ORs), also known as odorant receptors, are expressed in the cell membranes of olfactory receptor neurons and are responsible for the detection of odorants which give rise to the sense of smell. Activated olfactory receptors trigger nerve impulses which transmit information about odor to the brain. These receptors are members of the rhodopsin-like family of G protein coupled receptors (GPCRs). The olfactory receptors form a multigene family consisting of around 800 genes in humans.

Location: In vertebrates, the olfactory receptors are located in both the cilia and synapses of the olfactory sensory neurons and in the epithelium of the human airway.

Mechanism:

Rather than binding specific ligands, olfactory receptors display affinity for a range of odor molecules, and conversely a single odorant molecule may bind to a number of olfactory receptors with varying affinities, which depend on physiochemical properties of molecules like their molecular volumes. Once the odorant has bound to the odor receptor, the receptor undergoes structural changes and it binds and activates the olfactory type G protein on the inside of the olfactory receptor neuron. The G protein (G_{olf} and/or G_s) in turn activates the lyase - adenylate cyclase - which converts ATP into cyclic AMP (cAMP). The cAMP opens cyclic nucleotide-gated (CNG) ion channels which allow calcium and sodium ions to enter into the cell, depolarizing the olfactory receptor neuron and beginning an action potential which carries the information to the brain.

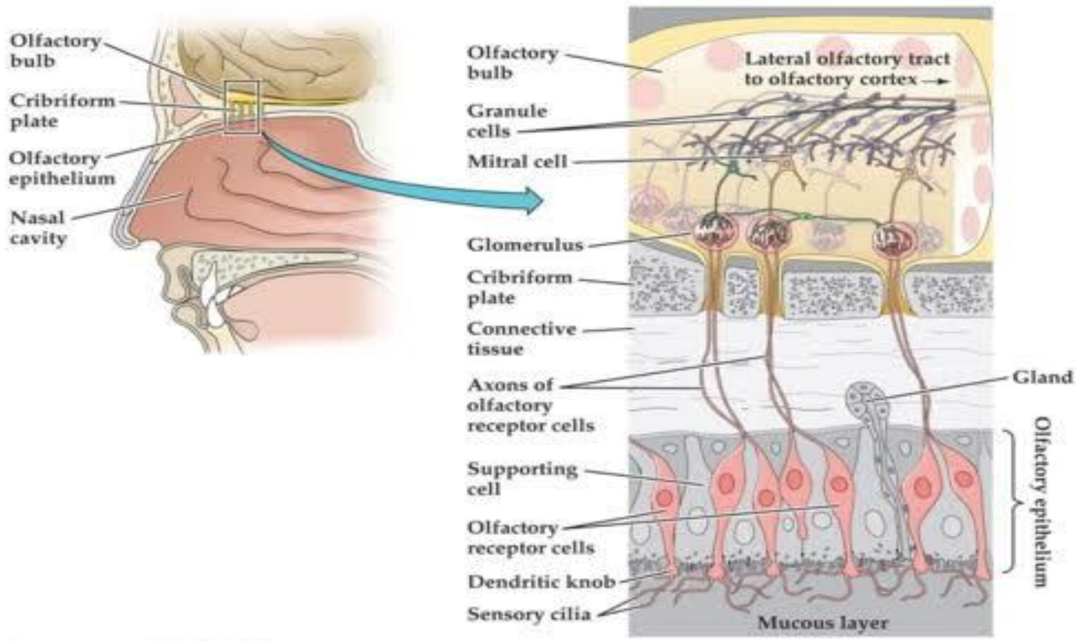


Fig: 1

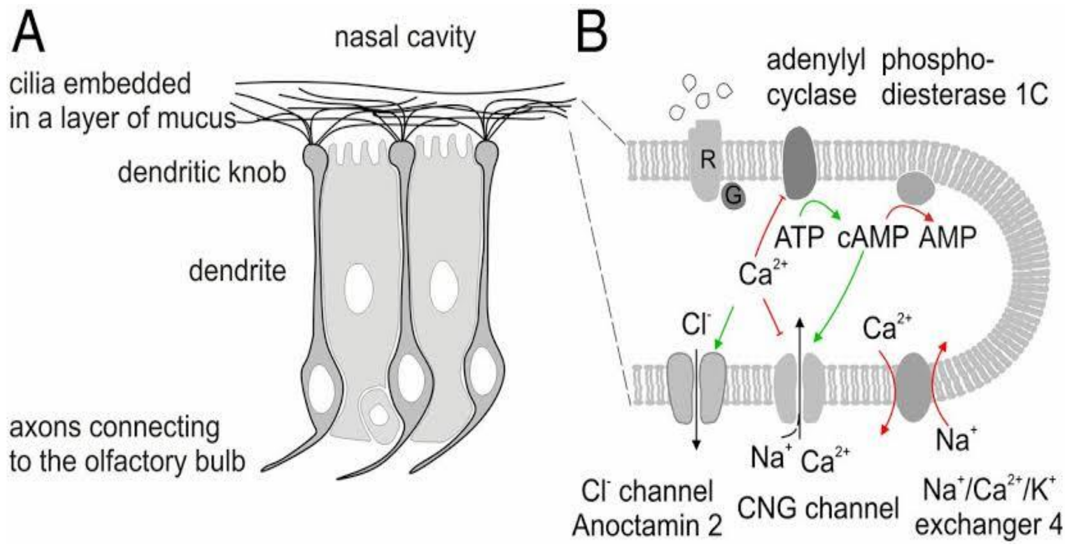


Fig: 2

Fig1: Anatomy of the nasal passage with different parts and olfactory neurons.

Fig2: Molecular pathway of olfaction in the cilia through GPCR.

Auditory receptors in vertebrate

In vertebrates, the number of auditory neurons always increases from the periphery (cochlea) to the centre (auditory cortex), by as much as four orders of magnitude.

Location and structure:

Sensory receptors of hearing are hair cells and associated organ is Organ of Corti present on basilar membrane of cochlea. Cochlea is a coiled structure. It is a bony tube on the outside, and a membranar tube is there on the inside. There is perilymph inside bony labyrinth and endolymph within membranar labyrinth. Perilymphatic space within bony labyrinth is divided in two parallel canals: scala vestibule (SV) and scala tympani (ST), due to presence of endolymphatic canal scala media (SM) (also called cochlear duct). SV and ST are connected at the tip of cochlear coil by a connecting passage named helicotrema. SV and SM are separated by Reissner's membrane while ST and SM are separated by Basilar membrane. Organ of Corti is located on basilar membrane and it is immersed in endolymph of SM (Fig 1 and 2). The vibrations are transferred from SV to ST via helicotrema.

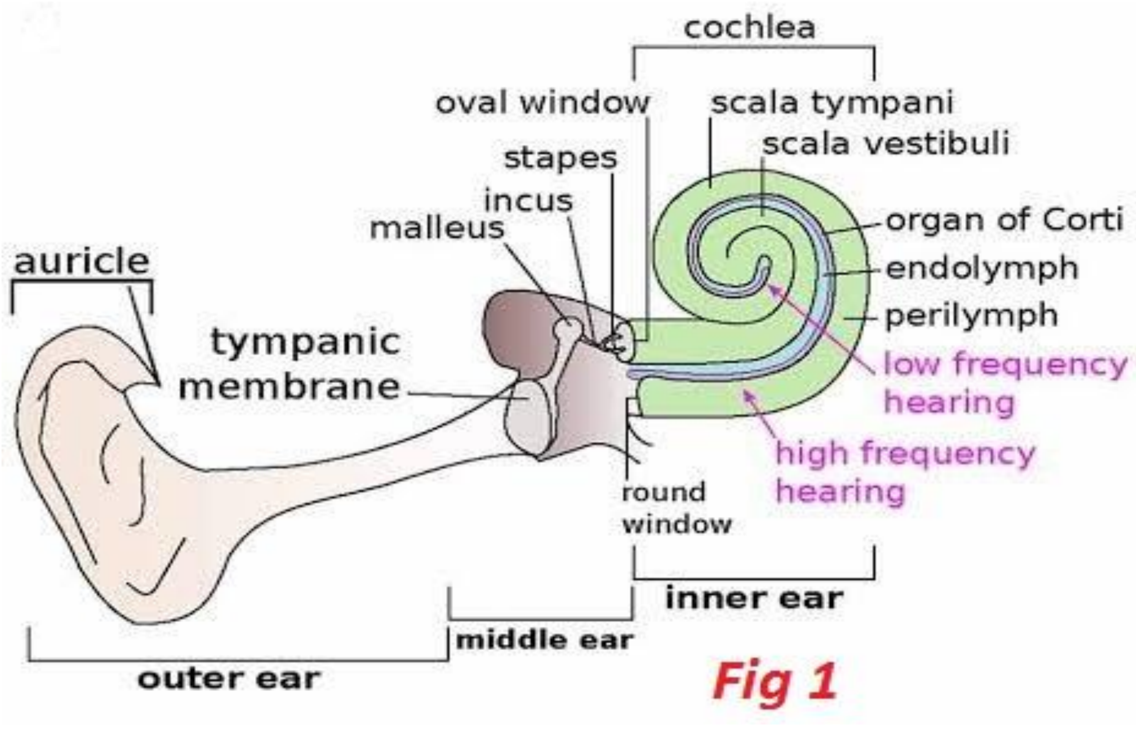
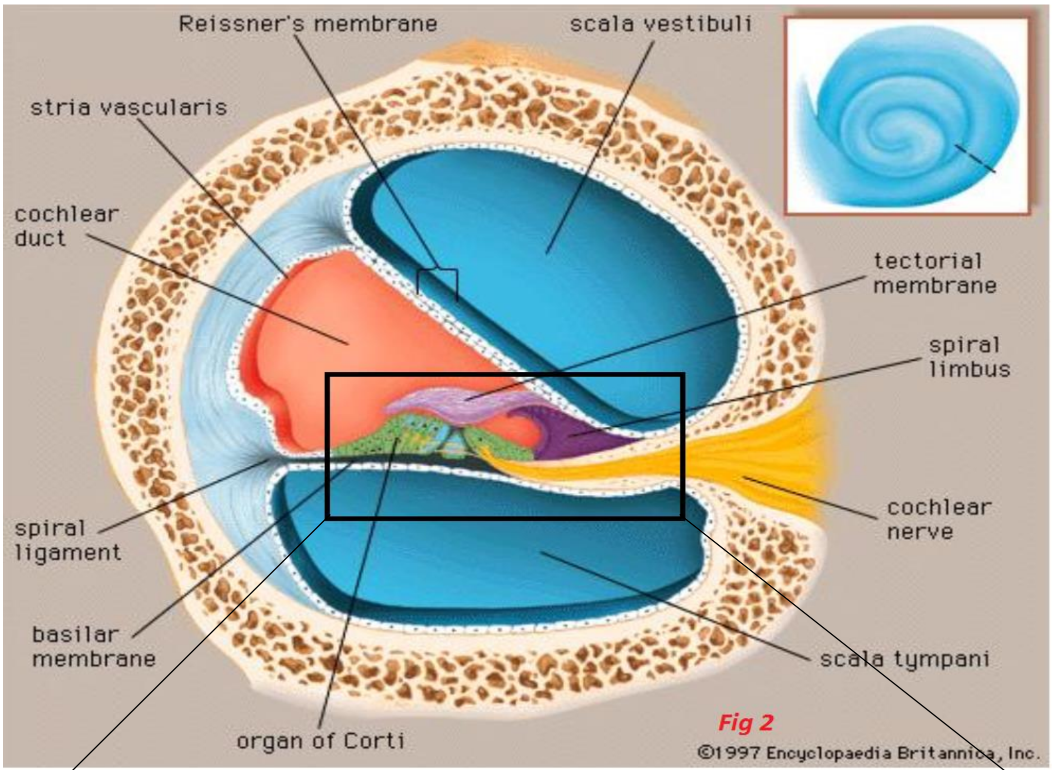


Fig 1



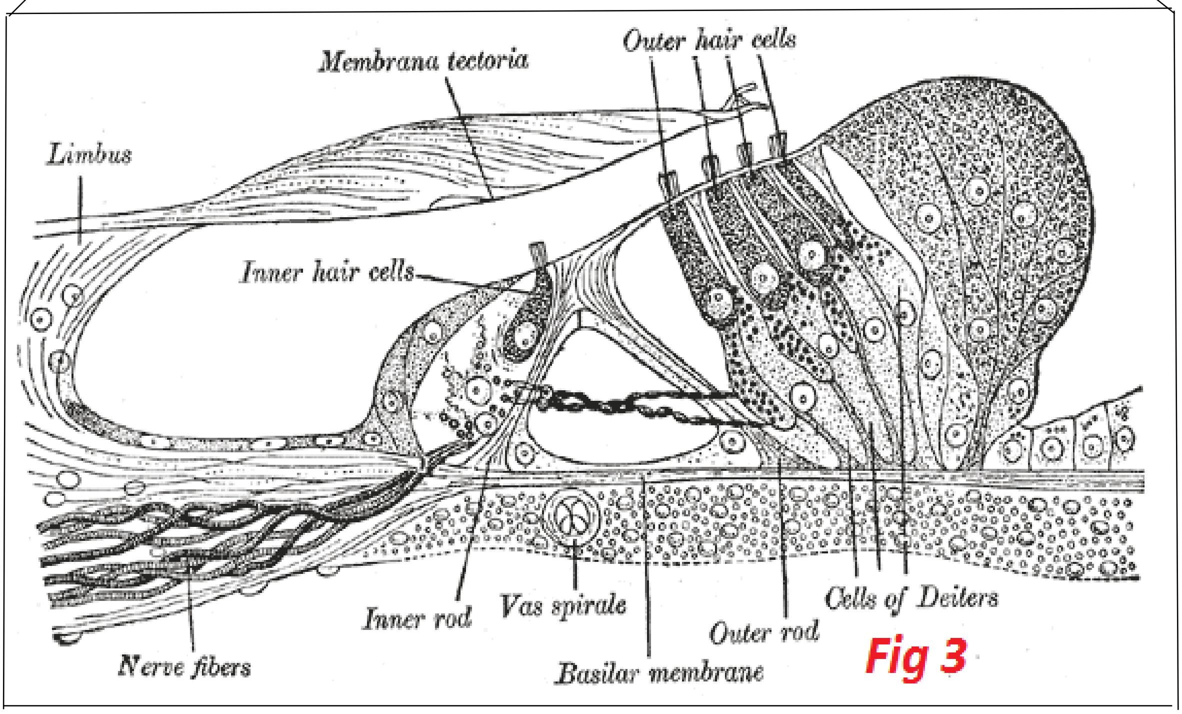


Fig 1: Outline anatomy of ear with different parts.

Fig 2: Section of cochlea showing different chambers.

Fig 3: Detailed structure of sensory part of cochlea showing hair cells (see mirror image of box portion of Fig 2).

Mechanism:

The inner ear consists of the cochlea, which is a spiral-shaped, fluid-filled tube. It is divided lengthwise by the organ of Corti, which is the main organ of mechanical to neural transduction. Inside the organ of Corti is the basilar membrane, a structure that vibrates when waves from the middle ear propagate through the cochlear fluid – endolymph. The basilar membrane is tonotopic, so that each frequency has a characteristic place of resonance along it. Characteristic frequencies are high at the basal entrance to the cochlea, and low at the apex. Basilar membrane motion causes depolarization of the hair cells, specialized auditory receptors located within the organ of Corti. While the hair cells do not produce action potentials themselves, they release neurotransmitter at synapses with the fibers of the auditory nerve, which does produce action potentials. In this way, the patterns of oscillations on the basilar membrane are converted to spatiotemporal patterns of firings which transmit information about the sound to the brainstem.