

The Ear

The ear is composed of 3 parts

Outer ear- Pinna, ear canal and tympanic membrane

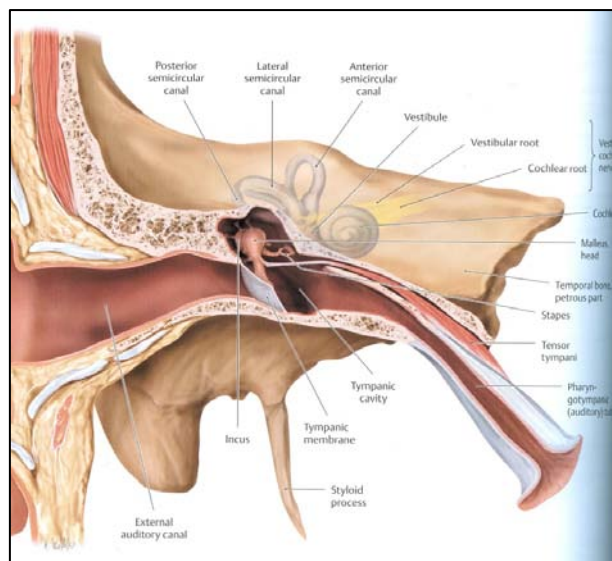
Middle ear- has the 3 bones (ossicles) - Malleus, Incus and stapes and connects to the nasopharynx thru the Eustachian tube

Inner ear- Made up of the semicircular canals and the cochlea – detection of linear and angular movement, balance and hearing.

Outer ear

This is made up of elastic cartilage. Size and shape differs in different species. In animals various muscles attached to the base of the ear control the movement of the pinna in order to detect and concentrate the sound waves. The pinna is clinically important in removal of small quantities of blood or for the injection of drugs- particularly in the pig and in wild animals- elephant, rhino- tranquilisation. The outer ear directs sound waves to the ear canal which is boot shaped in animals unlike the human. It is this boot shape that predispose the animal to wax accumulation or retention of foreign objects. Sometimes, aural resection (where the lateral wall of the boot cartilage is surgically cut off) has to be carried out to allow wax to drain easily in some dog breeds.

Ceruminous glands line the surface of the auditory tube (ear canal). Accumulation of cerumin can cause conduction deafness and needs to be cleaned. The outer ear and the inner ear are separated by the ear drum (tympanic membrane). Animals sometime get dust particles or small insects trapped in the ear canal and can cause a lot of disturbance and sometimes injury as the animal swings its head from side to side. The diagram below shows a longitudinal section thru the ear.



Clinical implications....stated above



Define Otitis externa

Which muscles are involved in the movement of the external ear?

Middle ear

There are 3 bones malleus, incus and stapes for mechanical transmission of sound. Two muscles, the stapedius attached to the stapes and the tensor tympani attached to the malleus when contracted stiffens the mechanical transmission system thereby decreasing the sound transmission into the inner ear. The stapedius is innervated by the facial nerve while the tensor tympani is innervated by a branch of the trigeminal nerve thru the medial pterygoid nerve.

The chorda tympani nerve which carries gustatory fibres to the anterior two thirds of the tongue pass thru the middle ear without any bony covering making it susceptible to damage in the event of trauma or surgery.

NB. The middle ear is connected to the nasopharynx thru the Eustachian tube. In the horse (equines generally), this is expanded in the distal aspect to form the guttural pouch. This is clinically important in the horse as it can become infected and inflamed causing discomfort. Infections may also spread to the nerves that pass very closely especially the sympathetic nerve from the cranial cervical ganglion. This can be a predisposing factor to the Horner's syndrome.



Name the nerves and major blood vessels that are close to the guttural pouch and explain the consequences of their inflammation or injury.

What is Horners syndrome?

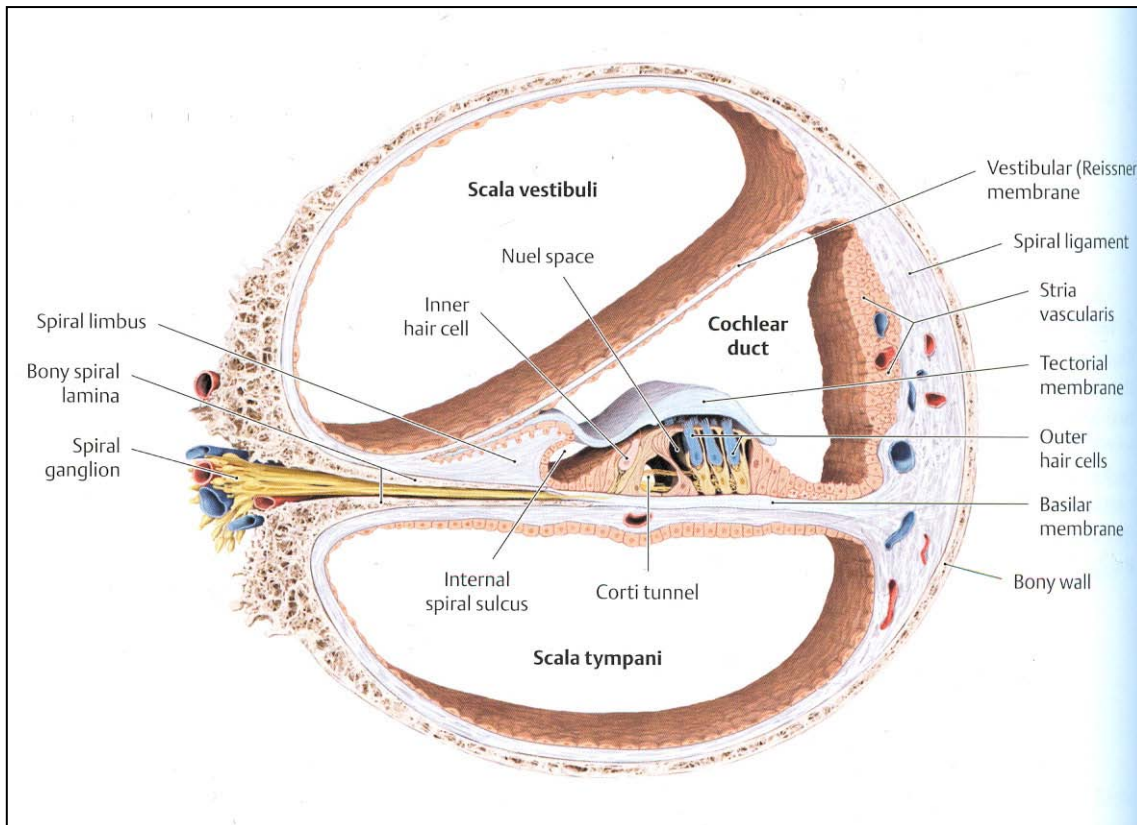
Inner ear

The bony canal of the cochlea is 30-35mm long and makes 2 1/2 turns around a bony projection, the modiolus which is perforated by branched cavities and contains the spiral ganglia.

A cross-section thru the cochlea shows membranous compartments arranged in three levels. The upper and lower compartments (*scala vestibule* and *scala tympani*) contains perilymph while the middle one, cochlea duct (*scala media*) contain endolymph. The perilymphatic ducts are interconnected at the apex by *helicotrema* while the endolymph

ends blindly. The bony lamina and basilar membrane form the floor of the cochlear duct on which the organ of Corti is located. The organ of Corti consists inner and outer hair cells covered by a gelatinous flap, the tectorial membrane. The hair cells bear stereocilia on their apical surfaces and these hair cells synapse with afferent and efferent neurons. The stereocilia transform the mechanical energy into electrochemical potentials.

The diagram below shows a section thru the cochlea



Sound conduction

A travelling wave is generated by vibrations on the oval window membrane. The wave causes deflection of the basilar membrane depending on the frequency. High frequency sounds are dissipated first at the base of the cochlea while low frequency ones are dissipated towards the apex where the basilar membrane is thicker. The deflections of the basilar membrane cause the outer and inner hair cells to shear against the tectorial membrane. The stereocilia of outer hair cells bend and in response they change their length and this increase the local amplitude of the travelling wave. This additionally bends the

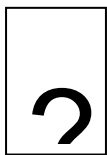
stereocilia of the inner hair cells stimulating the release of glutamate at their basal pole which in turn produce excitatory potentials on the afferent nerve.

Vestibular apparatus

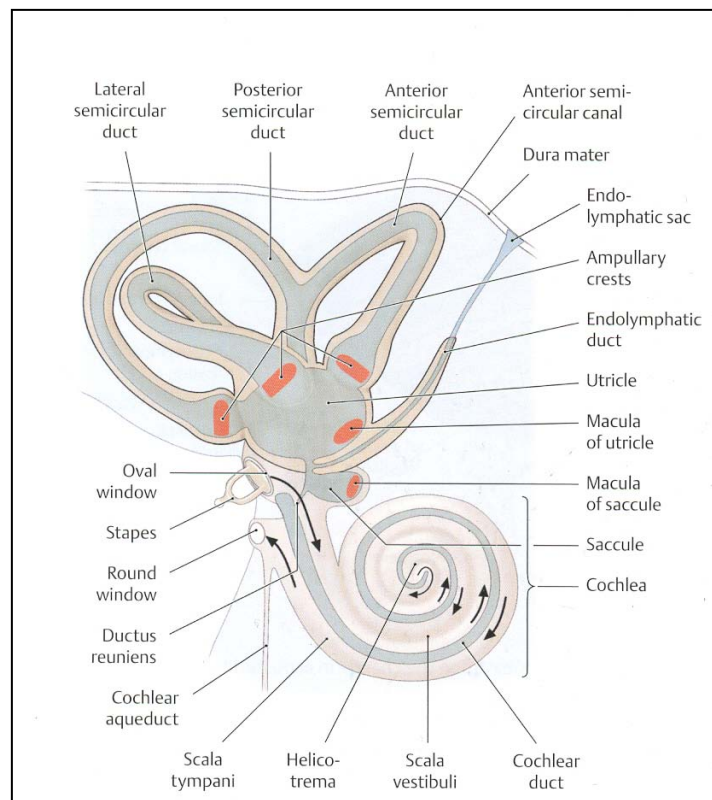
Organ of balance- Made up of the semicircular canals and the Sacculle and utricle. The semicircular canals detect angular movements while the saccule and utricle detect linear acceleration and gravity.

The semicircular canals

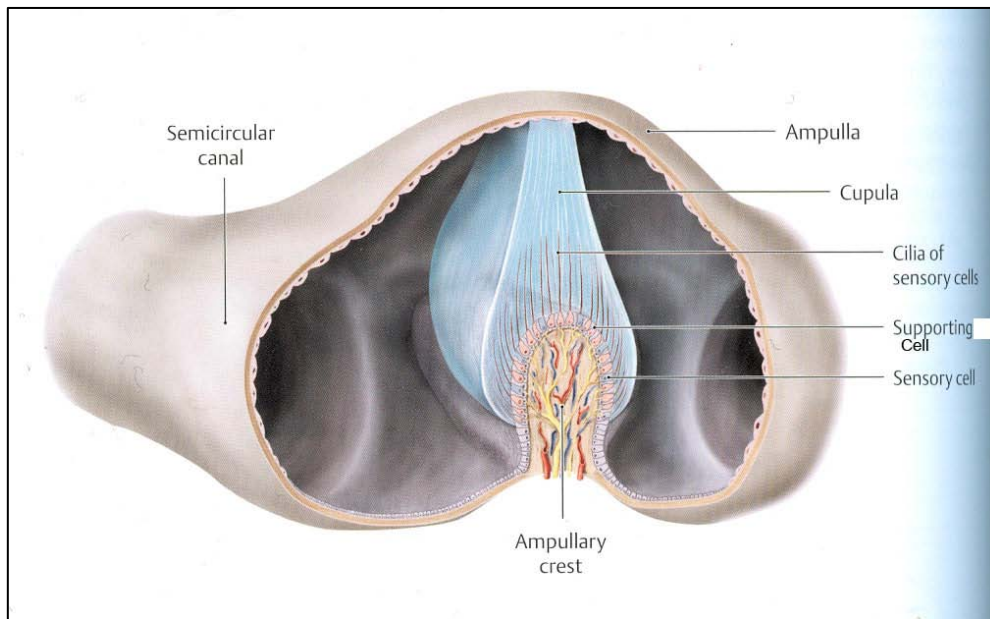
Contain sensory ridges in their dilated portions referred to as ampulla. The ampulla contain a sensory epithelium built on a ridge (ampullary crest). Extending above the crest is a gelatinous cupula which is attached to the roof of the ampulla. The sensory cells on the ampulla bear one long kinocilia and about 80 shorter stereocilia which project into the cupula. When the head is rotated in the plane of a particular semicircular canal, the endolymph cause a deflection of the cupula which in turn cause the bowing of the stereocilia. This causes depolarisation (excitation) or hyperpolarisation (inhibition).



Why is this depolarisation (excitation) or hyperpolarisation (inhibition) necessary on the same cells?



A schematic diagram showing the ampulla / Cupula



Utricule and Saccule

The above structures like the semicircular canals contain a special structure called the macula (maculae-pl). The macula contains rows of supporting and sensory cells. The sensory cells of the macula have specialised stereocilia which project into an otolithic membrane. The otolithic membrane is similar to the one of the ampulla (gelatinous) but contains calcium carbonate crystals (otoliths) embedded on its surface. Due to their high specific gravity, these crystals exert traction on the gelatinous membrane in response to linear acceleration which in turn produces a shearing movement of the stereocilia. Depolarization or hyperpolarisation results depending on the orientation of the cilia. The schematic diagram below shows position of the hair cells and the otoliths.

