Chapter 4 - Sense organs

The objectives of this chapter are:

1. Name the sense organs.
2. Distinguish between the special and general senses.
3. Describe the sense of smell.
4. Describe the sense of taste.
5. Describe the sense of sight.
6. Describe the sense of hearing and balance.
7. Describe the general senses.

1 - Generalities

Sense organs allow us to detect information from the world outside the body as well as from the body itself, enabling the nervous system to react properly.

We distinguish between special and general senses.

Special senses are perceived by specialised sense organs:

- smell is perceived by the nose,
- taste is perceived by the tongue,
- vision is perceived by the eyes,
- hearing is perceived by the ears,
- balance is perceived by the ears.

General senses are perceived by the receptors distributed throughout the body. They include touch, pain, temperature, pressure, vibration, and proprioception.

The cells or structures that detect sensations are called sensory receptors.
According to their structure, there are two types of sensory receptors:

- a neuron with either free nerve endings or encapsulated nerve endings; e.g. pain receptors, touch receptors and olfactory receptors in the nose detecting the smell;
- a specialised receptor cell; e.g. photoreceptors in the eyes detecting the light, taste receptors in the taste buds of the tongue and sound receptors in the ears.

Different sensory receptors detect different types of stimuli from varying sources. Information about the received stimulus is then transferred via sensory neurons to the central nervous system. Different types of stimuli therefore have to be transformed into an electrical signal. The process of transformation is called **transduction**. If the signal is strong enough, an action potential occurs and travels along the nerve fibre.

Sensory neurons transfer the received information into the central nervous system. Information from the special senses is transmitted along the cranial nerves, while information from the general senses is transmitted along the spinal or cranial nerves. The central nervous system enables integration of sensory stimuli and may lead to a motor response.

2 - Sense of smell

The sense of smell is perceived by the olfactory organ located in the nasal cavity. The olfactory receptors are free nerve endings of the olfactory neurones and act as chemoreceptors, perceiving the odour particles. They lie in the mucous membrane covering the roof of nasal cavity, called the olfactory mucosa.

The axons of the olfactory neurons pass through the cribriform plate of the ethmoid bone into the cranial cavity and end in the olfactory bulb where they synapse with the neurons of the olfactory nerve (cranial nerve I). The information finally reaches the temporal lobe of the cerebrum where the olfactory cortex is located.

The sense of smell is the oldest of the specialised senses.

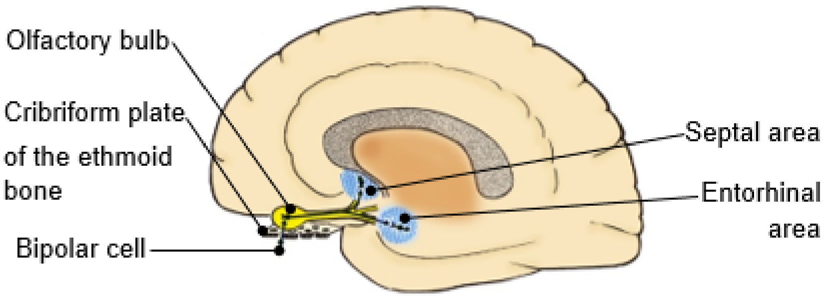

Figure 166: The olfactory pathway. Sagittal section of the brain, view from the left.

3 - Sense of taste

The sense of taste is perceived by the taste buds located in the tongue.

The dorsum of the tongue is covered with numerous small protrusions called papillae. Within the papillae lie the taste buds and within the taste buds lie the taste (gustatory) receptors. Similar to the olfactory receptors, the taste receptors are also chemoreceptors. They perceive chemical particles dissolved in saliva.

Taste buds are present in all three parts of the tongue: apex, body and root. The apex and the body form the anterior part of the tongue which is located in the oral cavity, while the root forms the posterior part of the tongue, which is orientated towards the oral part of the pharynx. The root and the body of the tongue are separated by a "V" shaped groove, called the terminal sulcus of the tongue.

Two cranial nerves are involved in the transfer of taste information into the central nervous system:

- Facial nerve (CN VII) conducts information from the apex and the body of the tongue.
- Glossopharyngeal nerve (CN IX) conducts information from the root of the tongue.

Information finally reaches the temporal lobe of the cerebrum where the olfactory cortex is located.

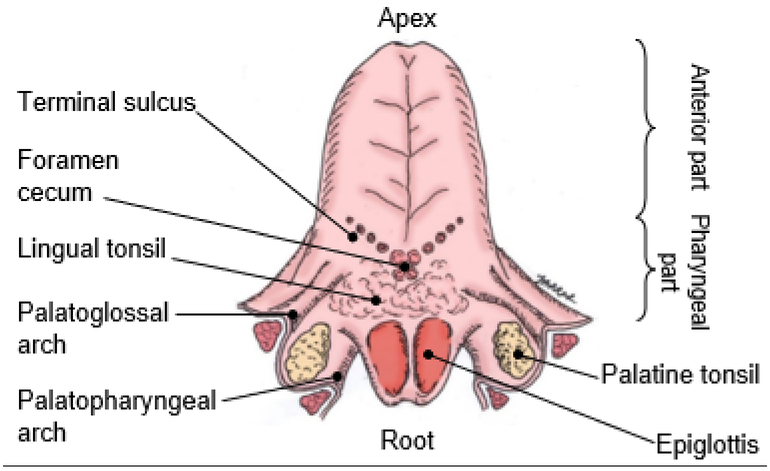

Figure 167: Superior view of the tongue.

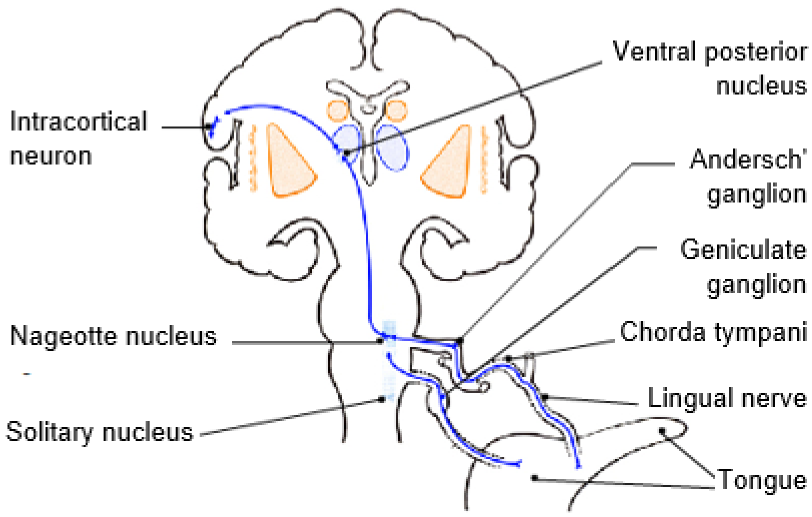

Figure 168: Taste pathway. Frontal section of brain.

Taste receptors detect four main taste sensations: sweetness, saltiness, sourness and bitterness. Historically, different tongue areas were stated to be specialised in the detection of a specific taste. Today, neurological evidence indicates that all areas of the tongue are responsive to all taste stimuli.

The perception of taste is closely related to the perception of smell.

4 - Sense of sight

The organ of sight is the eye which sits in the orbit. It is formed by the eyeball and the accessory visual structures.

Nerve impulses are conducted through the optic nerve (CN II). Information finally reaches the occipital lobe of the cerebrum where the visual cortex is located.

4.1 - Eyeball

The eyeball is designed to receive visual impulses. It has a form of an imperfect sphere. We distinguish two poles of the eyeball, the anterior and the posterior one. Transparent structures of the eyeball allow the light to enter the eyeball and reach the photoreceptors which respond to light.

The eyeball consists of three layers (tunics) enveloping the contents inside.

Fibrous tunic of the eyeball

Fibrous tunic is the outermost protective layer of the eyeball, providing the shape of the eyeball and the protection of deeper structures. It is composed of two parts:

- Sclera, which is opaque and forms the majority of the fibrous tunic.
- Cornea, which lies anteriorly, is transparent and forms less than 10 % of the fibrous tunic. Part of the cornea that borders sclera is named corneoscleral junction or corneal limbus.

Vascular tunic of the eyeball

Vascular tunic is the middle layer of the eyeball, composed of three parts that are continuous with each other:

- Choroid contains vessels, providing the blood supply. It forms the majority of the vascular tunic.
- Ciliary body lies anteriorly to the choroid. It produces a transparent fluid (aqueous humour) which nourishes the anterior parts of the eyeball and maintains the pressure inside the eyeball (intraocular pressure). The ciliary body also contains the ciliary muscle which enables the eye to adjust its focus to clearly see the objects at different distances (accommodation of the eye).
- Iris is the anterior part of the vascular tunic. It is pigmented and has a form of a ring; the circular opening in the centre of this ring is the pupil. The iris contains two muscles that can change the diameter of the pupil and thus control the amount of light entering the eyeball.

Inner tunic of the eyeball

Inner or neural tunic of the eyeball is called retina. It contains the photoreceptors which absorb the light and convert the light impulses into the neural impulses. It also contains the nerve cells. The nerve fibres finally merge to form the optic nerve.

Structures inside the eyeball tunics

The eyeball tunics envelop the transparent structures that transmit the light:

- The anterior and posterior chamber of the eyeball are filled with aqueous humour and communicate with each other through the pupil. The anterior chamber lies between cornea and iris, and the posterior chamber lies between iris and lens.
- The lens is a transparent, biconvex, elastic body and lies between iris and vitreous body. Fibres that connect lens to the ciliary body hold the lens in place and transmit the force

produced by ciliary muscle that leads to a change of lens shape and the accommodation of the eye.

- The vitreous body is gelatinous transparent structure filling the majority of the eyeball.

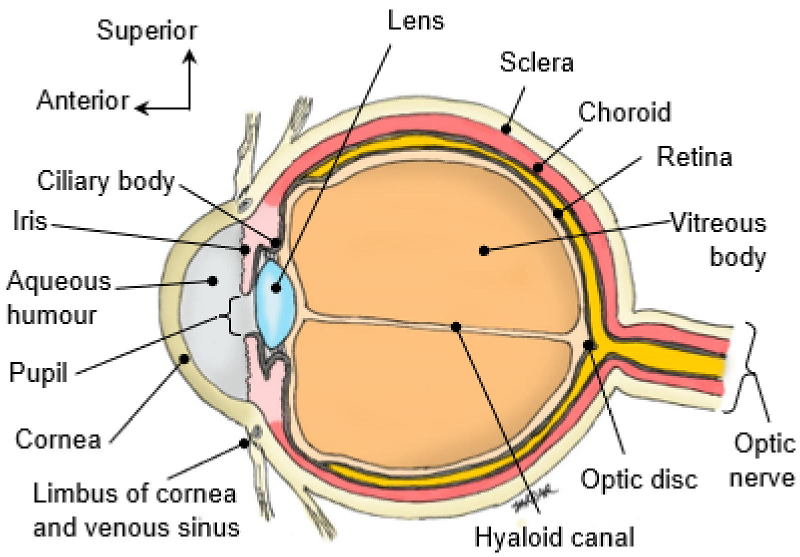

Figure 169: Sagittal section through the eyeball.

4.2 - Accessory visual structures

Accessory visual structures are indispensable for the normal functioning of the eye, protecting and supporting the eyeball and enabling the movements.

Extraocular muscles

There are seven extraocular muscles in the orbital region. Six of them are attached to the eyeball enabling it to move in almost every direction.

One of the extraocular muscles ends in the upper eyelid and elevates the upper eyelid. All muscles are striated, innervated by the somatic nervous system and therefore acting under conscious control.

Accessory structures for protection and support

- Conjunctiva is a thin transparent mucous membrane that lines the inner surface of the eyelids and the anterior surface of the eyeball with the exception of cornea.
- Upper and lower eyelid are thin movable folds that protect the eyeball from trauma and excessive light, and maintain the eyeball moist through blinking which smears the tears over the cornea.
- Lacrimal apparatus includes the lacrimal gland and the lacrimal ducts. The gland produces the tears and the ducts drain the tears into the nasal cavity.
- Orbital fat body fills the remaining orbital space between the eyeball, extraocular muscles, nerves and vessels, protecting and supporting them.

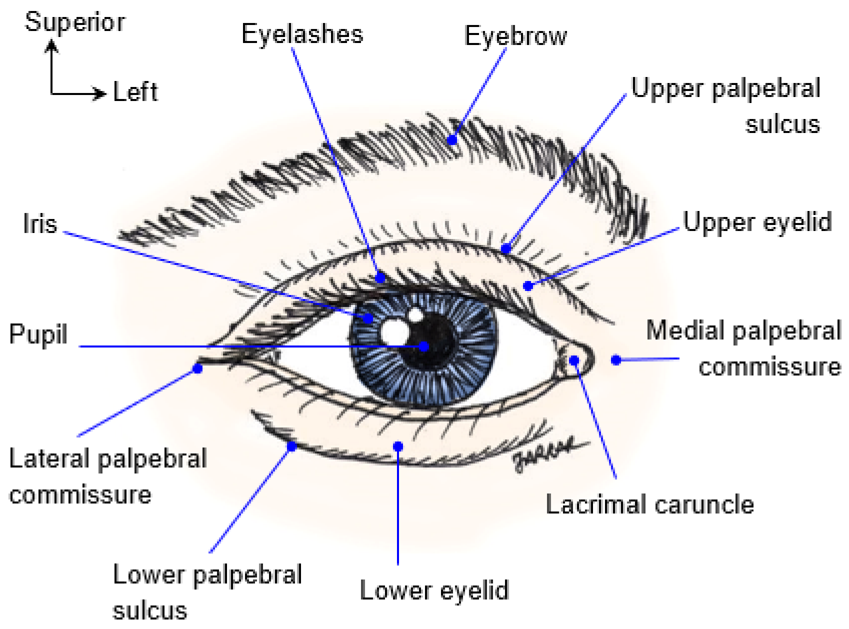

Figure 170: Front view of the right eye.

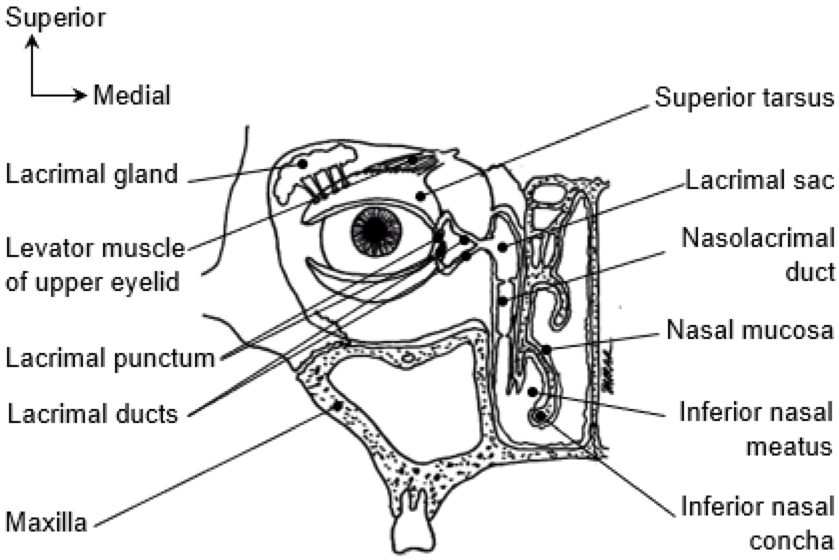

Figure 171: Overview of the lacrimal apparatus. Frontal section through the right orbita and right nasal cavity.

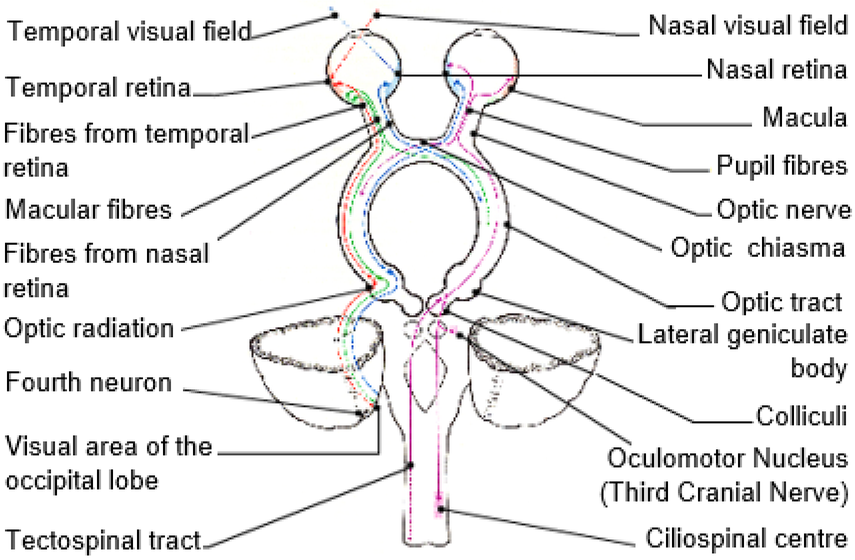

Figure 172: The visual pathway.

5 - Sense of hearing and balance

The organ of hearing is the ear. It is divided into the external, middle, and internal ear. The internal ear is also the organ of balance.

Nerve impulses are conducted by the vestibulocochlear nerve (CN VIII).

Information finally reaches the temporal lobe of the cerebrum where the auditory cortex is located.

External ear

The external ear is designed to collect and conduct the sound waves. It consists of:

- auricle,
- external acoustic meatus,
- tympanic membrane (the eardrum).

After passing through the external acoustic meatus, the sound waves hit the tympanic membrane causing its vibration.

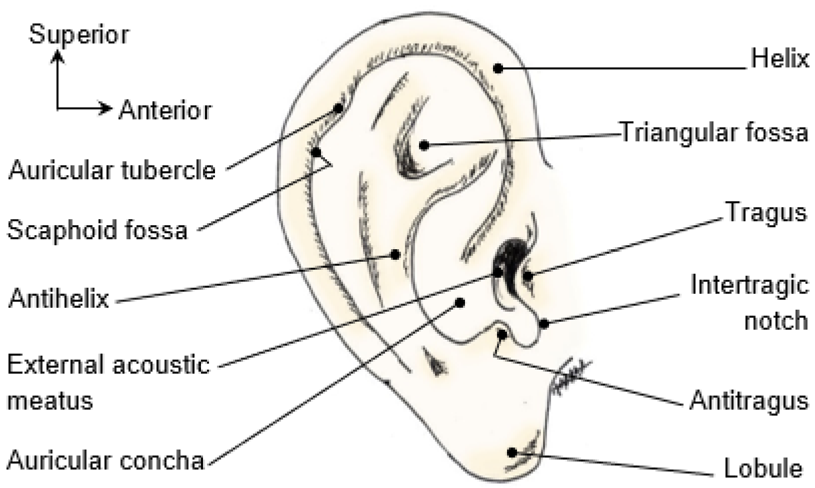

Figure 173: Lateral view of the right auricle.

Middle ear

The middle ear transmits sound vibrations from tympanic membrane to the inner ear. It is composed of:

- tympanic cavity, inside which there are three auditory ossicles joined by synovial joints, and two muscles of auditory ossicles;
- auditory tube.

Vibrations of the tympanic membrane are transmitted through the tympanic cavity along the three auditory ossicles. Contraction of the muscles of auditory ossicles occurs when the sound is too loud and it prevents excessive movements of the auditory ossicles that could lead to hearing impairment.

The auditory tube, also called the Eustachian tube, connects the tympanic cavity with the pharynx and enables equalisation of pressure on both sides of the tympanic membrane thus preventing its damage.

Internal ear

The internal ear lies inside the temporal bone and consists of:

- cochlea – the organ of hearing,
- vestibule and three semicircular canals – the organ of balance,
- internal acoustic meatus.

Inside the cochlea is organ of Corti, which contains the sound receptor cells.

Inside the vestibule are the receptor cells for static balance and inside the semicircular canals are the receptor cells for dynamic balance.

Inside the internal acoustic meatus lies the vestibulocochlear nerve.

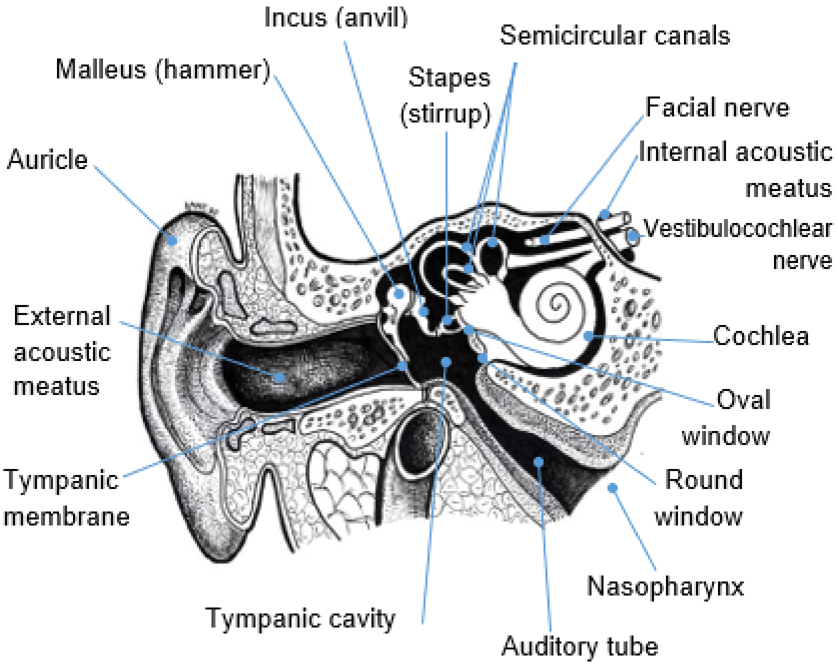

Figure 174: The external, middle and internal ear.

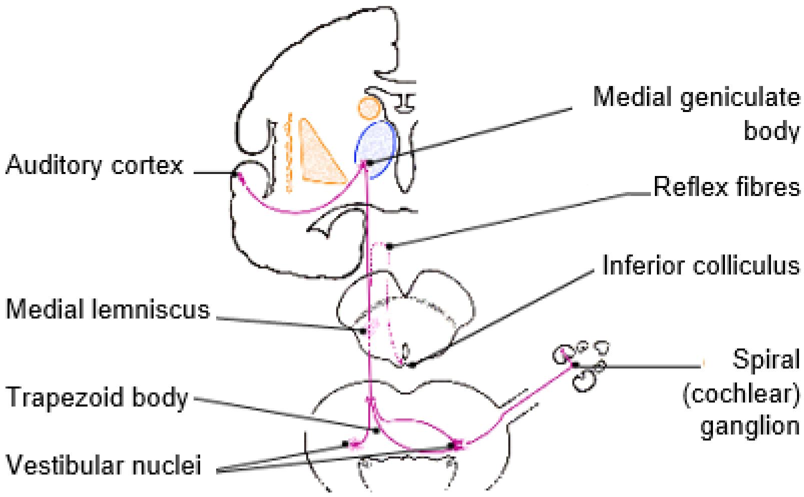

Figure 175: The auditory pathway.

6 - General senses

General senses are perceived by the receptors in the skin, muscles, tendons, joint capsules, ligaments, walls of visceral organs, etc.

The receptors in the skin provide information about the body environment. There are different types of receptors in the skin; some are free nerve endings of the sensory neuron, while others are encapsulated. They perceive different mechanic impulses (mechanoreceptors), temperature information (thermoreceptors) and pain (nociceptors).

The skin is composed of three layers:

- epidermis (avascular surface layer),
- dermis,
- hypodermis.

In addition to its role as a sense organ, the skin also performs several other functions, such as protection and thermoregulation.

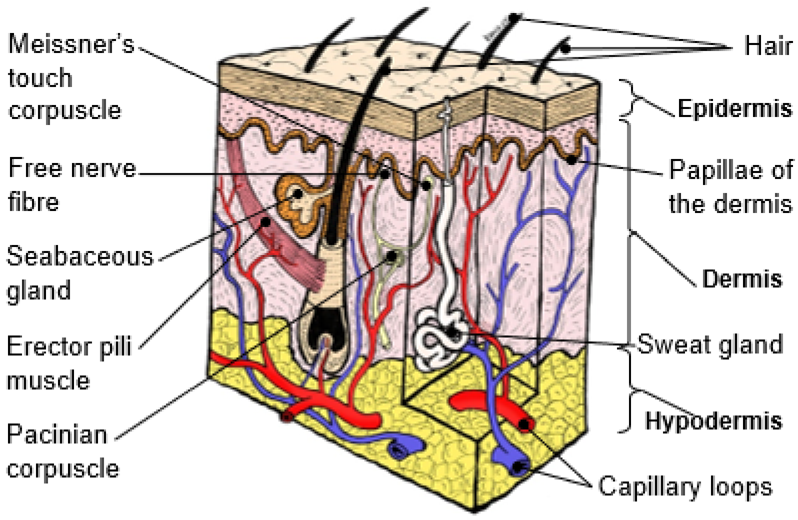

Figure 176: Diagram of the skin.

Sensory innervation is provided by the sensory nerves. Each spinal nerve supplies its own skin area, called the dermatome.

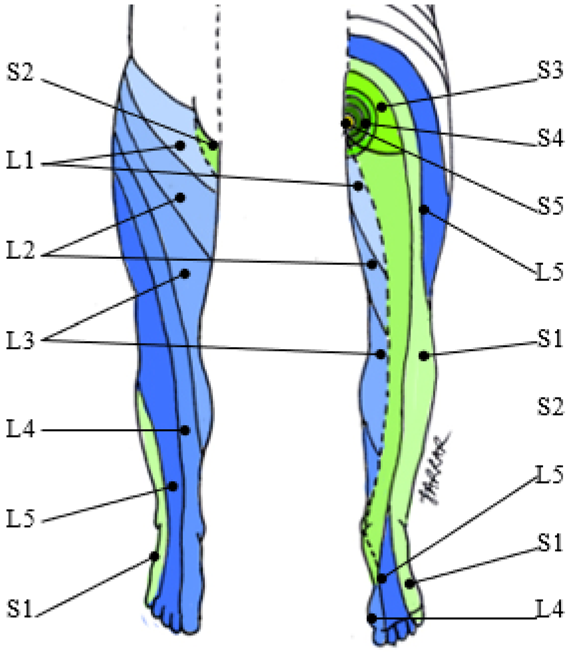

Figure 177: Dermatomes of the lower limb.

There are also numerous receptors in the musculoskeletal system, called the proprioceptors. The purpose of proprioception is to provide information about the position of body parts in space, accurate performance of movements and to protect the musculoskeletal system.