Unit 1: Maintaining Dynamic Equilibrium (II)
The Nervous System

Cells, tissues, organs and ultimately organ systems must maintain a biological balance despite changing external conditions.

**Homeostasis** is the state of internal balance so critical to existence. It represents a dynamic equilibrium displaying constant interactions and checks / balances both within organisms and between organisms and their environment.

Structure and function of the nervous system

The Nervous system is comprised of two divisions/Sections

**Central Nervous System (CNS):** brain and spinal cord.
The CNS receives sensory information and initiates motor control.

**Peripheral Nervous System (PNS):** includes nerves that lead into and out of the CNS.

It consists of the autonomic nervous system and the somatic nervous system.

1. **Autonomic Nervous System:**
The autonomic nervous system is not consciously controlled and is made up of the sympathetic and parasympathetic nervous systems.

2. **Somatic nervous system:**
Made up of sensory nerves that carry impulses from the body’s sense organs to the CNS. It consists of motor nerves that transmit commands from CNS to the muscles and deals primarily with the external world and the changes in it. It is able to control subtle reflexes such as blinking which does not require a conscious decision.

How is the nervous system protected?

The brain is protected by:
(1) the skull or cranium;
(2) meninges — series of three membranes that surround brain and spinal cord;
(3) cerebrospinal fluid — fills spaces in meninges to create a cushion.

The spinal cord is protected by:
(1) vertebrae
(2) cerebrospinal fluid.
The Brain

The brain has three main parts:

1. cerebrum
2. cerebellum
3. brain stem.

The brain is divided into regions that control specific functions.

**Cerebrum**: the part of the brain where all information from our senses is sorted and interpreted. Voluntary muscles that control movement and speech are stimulated from this part of the brain. Memories are stored and decisions are made in this region. It is the center of human consciousness and separates us from every other animal on the planet.

The Cerebrum is divided into two Hemispheres (left and Right) and 4 lobes ➔ Frontal, Parietal, Occipital and Temporal.

**Cerebellum**: controls muscle coordination. It contains 50% of the brain’s neurons but only makes up 10% of brain volume. It controls our balance. We do not have to think about certain skills as we get older because they are controlled by the cerebellum.

**Medulla Oblongata**: attached to the spinal cord at the base of the brain and has a number of functions all related to a particular structure. The cardiac center controls heart rate and force of contractions. The vasomotor center adjusts blood pressure by controlling blood vessel diameter. The respiratory center controls rate and depth of breathing. It also contains reflex centers for hiccupping, vomiting, coughing and swallowing. Damage to this part of the brain is usually fatal.

**Thalamus**: the sensory relay center. It receives information such as touch, pain, heat, cold as well as information from the muscles. Mild sensations are relayed to the appropriate part of the cerebrum (conscious part of the brain). If sensation is strong, the thalamus triggers a more immediate reaction while transferring the sensations to the homeostatic control center, the hypothalamus.

**Hypothalamus**: A complex bundle of tissue that acts as the main control center for the autonomic nervous system. It enables the body to respond to external threats by sending impulses to various organs via the sympathetic nervous system. After the threat has passed, it reestablishes homeostasis by stimulating the parasympathetic nervous system.

**Midbrain**: A short section of brainstem between the cerebrum and the pons. It is involved in sight and hearing.

**Pons**: Contains bundles of axons traveling between the cerebellum and rest of CNS. It works with the medulla to regulate breathing rate and has reflex centers involved in head movement.

**Corpus callosum**: is a series of nerve fibers that connect the left and right hemispheres of the brain.
The Spinal Chord

Extends from the base of the brain all the way down the vertebral column.

Surrounded by the vertebral column that protects it.
Consists of White and Grey matter. Grey matter is comprised of nonmyelinated neurons. White matter contains myelinated neurons.
Contains a ventral and dorsal root for each nerve. Dorsal root receives sensory impulses and transfers them to the brain. The Ventral root sends out motor impulses from the brain to the effectors (glands or muscles)

Reflex Acts and Arcs

Reflex act: An automatic involuntary response to a stimulus – a reflex.

Reflex arc: It is a nerve path that leads from a stimulus to a reflex action.
(A) Sensory neuron receives a stimulus (such as heat or pain) that triggers nerve endings in hand. The nerve endings are dendrites of a sensory neuron. A strong stimulus is required to activate the neuron.
(B) An impulse travels along this neuron and goes to the spinal cord where the signal is passed on to interneurons — (link between sensory and motor neurons).
(C) A motor neuron is stimulated and transmits an impulse along its axon. The motor neuron triggers contractions of muscles in your arm and you pull your hand away.
(D) While this happens, other interneurons in the spinal cord transmit a message to your brain making you aware of what has happened.

Peripheral Nervous System

It consists of the autonomic nervous system and the somatic nervous system.

The autonomic nervous system is not consciously controlled and is divided into: (a) sympathetic nervous system; (b) parasympathetic nervous system.

Sympathetic nervous system: It sets off a “fight or flight” response to deal with an immediate threat. When stimulated, heart rate and breathing rate increases and blood sugar is released by the liver. It can be good and bad — test anxiety.

Parasympathetic Nervous System: It has the opposite effect of the sympathetic nervous system. When threat has passed, nerves of this system slow heart rate and breathing rate.

Conditions Necessary for a Nervous Response?
These four things must occur — (1) Sensory receptors to detect a stimulus (skin, eye, ear);
(2) Method for impulse transmission (neurons);
(3) Interpretation of analysis of impulses (brain and spinal cord);
(4) Response carried out by an effector (muscle, gland).
Neurons (nerve cells)

Neurons are the structural and functional unit of the nervous system. Neurons are cells that send and receive electro-chemical signals to and from the brain and nervous system. There are about 100 billion neurons in the brain. Unlike most other cells, neurons cannot regrow after damage. Fortunately, there are about 100 billion neurons in the brain. They can transmit nerve signals to and from the brain at up to 200 miles/h (or 267 km/h). There are many type of neurons. They vary in size from 4 microns (0.004 mm) to 100 microns (0.1 mm) in diameter. Their length varies from a fraction of an inch to several feet.

Points of Interest: PNS consists of nerves or numerous neurons held together by connective tissue. CNS is also made up of neurons and contain 90% of body’s neurons.

Text reference — Axon (Figure 12.6, p. 395).

Neurons consist of three basic parts: (1) Cell body; (2) Dendrites; (3) Axon.

Dendrites are the primary site for receiving signals from other neurons. Depending on the neurons function, the number can range from one to thousands.

Cell body has a large centrally located nucleus and a large nucleolus. It’s cytoplasm contain many mitochondria along with a Golgi complex and rough ER.

Neurons are capable of surviving for over 100 years since many do not undergo cell division after adolescence

Axon is a long cylindrical extension of the cell body than can range from 1mm to 1 m. It transmits waves of depolarization along its length and at the end of the axon are structures that release chemicals

Axon terminal is the bulb like ends of the axon, (end brushes or terminal ending).

Schwann Cells insulate cells around an axon. It speeds up waves of depolarization. It is covered with a fatty layer called myelin sheath. Each Schwann cell is separated by a gap called the node of Ranvier.

A myelinated neuron enables nerve impulses to jump from one node of Ranvier to the next speeding up the wave of depolarization to about 120 m/s — (many signals only move at 2 m/s). This is called Saltatory Conduction

Schwann cells also have an important function. Most mature neurons do not reproduce. If the outer layer of Schwann cell (neurolemma) is present in a neuron, the cell is capable of regenerating if the damage is not too severe. If a neuron is cut, the severed end of the axon grows a number of extensions or sprouts and the original axon grows a regeneration tube from its neurolemma If one of the sprouts connects with the regeneration tube, the axon can re-form itself. * CNS neurons do not regenerate.
Neuron Types

(1) **Sensory neurons** take information from a receptor (e.g., pain) to CNS. They require a strong stimulus.

(2) An **interneuron** is a nerve cell that acts as a link between a sensory neuron and a motor neuron. It receives information from other interneurons and from sensory neurons.

(3) **Motor neurons** take information from the CNS to an effector, such as a muscle or gland.

![Neuron Diagram](image)

How a neuron works

**Resting Potential/Resting Neuron**

When a Neuron is at rest it normally has a positive (+) charge on the outside of the membrane while having a negative (-) charge on the inside. There is a voltage difference of -70 mV referred to as the **Resting Potential** or **Threshold level** that exists in this condition.

*How is Resting Potential Achieved?*

The outside has high concentrations of sodium ions and lower concentrations of potassium ions. Chlorine which has a negative charge is also outside the membrane. Inside the cell there are proteins, amino acids and phosphates and sulfates which have a negative charge. The positive charges inside the membrane are caused by a high concentration of potassium and a lower concentration of sodium. The membrane has specialized channels for the movement of sodium, potassium and chlorine, but proteins and amino acids (larger anions) are trapped inside the cell.

At rest, the membrane is 50 times more permeable to potassium than to sodium which means that while sodium is moving into the cell there is more potassium diffusing out of the cell. When this happens this causes the inside of the cell to become more negatively charged. Although the increasing negative charge within the cell attracts both the sodium and the potassium the sodium - potassium...
pump found in the cell membrane offsets this attraction. The pump uses active transport to pull three sodium cations from the inside of the cell to the outside and in exchange two potassium cations are pulled from the outside to the inside and thereby increasing the difference in the charge. The slight difference in charge is due to the unequal distribution of cations and anions. The difference in charge is about -70 mV and is referred to as the resting potential.

**Depolarization**:

When a neuron is sufficiently stimulated (Beyond the threshold level) the following occurs:
1. A wave of depolarization is triggered;
2. Gates of potassium channels close and the gates of the sodium channels open;
3. Sodium ions rush into the axon; this causes a change in the charge on the outside and inside of the axon (outside becomes negative, inside becomes positive);
4. This change in charge is called the action potential;
5. The depolarization of one part of the axon causes the gates of neighbouring sodium channels to open and continues along the length of the axon.

**Repolarization**: - The reestablishment of the normal distribution of ions in an axon (+ outside/- inside)

1. Axons are only depolarized for a split second;
2. Immediately after the sodium channels have opened to cause depolarization the gates of the potassium channels re-open and potassium ions move out;
3. The sodium channels close at the same time;
4. This action combined with the rapid active transport of sodium out of the axon by the sodium potassium pump re-establishes the polarity of that region of the axon.

The speed of which this process occurs allows an axon to send many impulses along its length every second if stimulated sufficiently.

**Refractory Period**

The brief time between the triggering of an impulse along an axon and when it is available for the next is called the refractory period. No new action potentials can occur during this time.

Myelin increases the speed of a wave of depolarization.

The threshold is a strong enough stimulus to fire a neuron. The strength of the stimulus does not affect the speed of the response. The neuron either fires or it doesn’t (all or none response) — (for example, pulling harder on the trigger of a gun does not affect the speed of the bullet).

All or none principle (for nerve impulses):

If an axon is stimulated sufficiently (above the threshold) the axon will trigger an impulse down the length of the axon.
The Synapse

Neurons do not touch each other. They have tiny gaps between them called synapses. The presynaptic neuron carries wave of depolarization toward the synapse. The postsynaptic neuron receives the stimulus.

How does the wave cross the synapse?

1. Wave of depolarization reaches the end of presynaptic axon.
2. It triggers opening of special calcium ion gates.
3. Calcium triggers the release of neurotransmitter molecules (by exocytosis).
4. Neurotransmitter is released from special vacuoles called synaptic vesicles.
5. Neurotransmitter diffuses into the gap between the axon and the dendrites of the neighbouring postsynaptic neurons.
6. Neurotransmitter attaches to receptors on dendrites and excites or inhibits the neuron.

NOTE: An excitatory response opens the sodium gates and triggers a wave of depolarization. Inhibitory response makes the postsynaptic neuron more negative on the inside which raises the threshold of the stimulus.

Neurons can stimulate more than other neurons — muscles and glands are also simulated in the same way. Muscles contract. Glands secrete substances such as hormones.

Neurotransmitters

Acetylcholine is a primary neurotransmitter of somatic nervous system and parasympathetic nervous system. It can have excitatory or inhibitory effects — for example, it stimulates skeletal muscles and inhibits cardiac muscle.

1. Noradrenaline (also called norepinephrine) is the primary neurotransmitter of the sympathetic nervous system — (fight or flight).
2. Glutamate is a neurotransmitter of the cerebral cortex that accounts for 75% of all excitatory transmissions from the brain.
3. GABA (gamma aminobutyric acid) is the most common inhibitory neurotransmitter of the brain.
4. Dopamine elevates mood and controls skeletal muscles.
5. Serotonin is involved in alertness, sleepiness, thermoregulation and mood.

NOTE: Cells within the nervous system require enormous amounts of energy to function. This energy is provided with the processing of glucose and the production of ATP within these tissues, requiring an adequate supply of carbohydrates and oxygen. ATP energy is required to operate the sodium potassium pump which converts cellular chemical signals into electrical signals along a nerve cell and between them (synapse).
Disorders of the Nervous System

1) **Multiple Sclerosis (MS)**

It affects nerve cells surrounding brain and spinal cord. The myelin becomes inflamed or damaged and disrupts impulses. Some symptoms are: blurred or double vision, slurred speech, loss of coordination, muscle weakness, tingling or numbness in arms and legs, and seizures. MS attacks occur in episodes where symptoms become worse alternating with periods where the symptoms improve. Many people have MS which is rapid and severe. MS is believed to be an autoimmune disorder where the immune system attacks the myelin sheaths of the body’s own nerve cells. At present there is no cure, but treatment involves medication to suppress the autoimmune reaction.

2) **Alzheimer’s Disease**

It causes impairment of brain’s intellectual function such as memory and orientation. The brain gradually deteriorates causing memory loss, confusion, and impaired judgement. Alzheimer’s results from protein deposits called amyloids that distort the communication paths between brain cells. Also, acetylcholine levels begin to drop causing further breakdown of communication. There is no present means of prevention, but cholinesterase inhibitors are given to increase the levels of acetylcholine and to improve intellectual function.

3) **Parkinson’s disease**

It is a chronic movement disorder caused by the gradual death of cells that produce dopamine. Remember that dopamine carries messages between the areas of brain controlling body movements. The symptoms begin as tremors in one side of the body and as disease progresses, the tremors spread to both sides of the body causing the limbs to become rigid, body movements to slow and an abnormal gait to develop. By the time the first symptoms develop, 70 - 80 % of the brain cells that produce dopamine have already been lost. Treatments involve medication to boost dopamine levels — (sadly, long term use can impair mental abilities). Also, small lesions in the brain can be created by surgeons or implanting electrodes in parts of brain that are overactive.

4) **Meningitis**

It is a viral or bacterial infection of the meninges. Viral meningitis is common in children and usually clears after 7-10 days. If not treated immediately, the more serious bacterial meningitis is usually fatal. Symptoms include: headache, fever, and a stiff neck, light sensitivity, drowsiness, and vomiting. It is diagnosed by testing the cerebrospinal fluid that surrounds the spinal cord for the presence of the bacteria or immune system activity (spinal tap or lumbar puncture). Vaccines are available for bacterial meningitis, but it can have severe long-lasting effects such as hearing impairment. Fatality rates are 10%.

5) **Huntington’s Disease (or Huntington’s Chorea)**

It is a fatal autosomal dominant disorder in which the nerve cells in certain parts of the brain deteriorate. It causes major progressive decreases in mental and emotional abilities and loss of control over major muscle movements. Each child of a parent with Huntington’s has a 50 % chance of inheriting the disorder. There is no cure at present and no way to slow its progression. Symptoms include: memory loss, dementia, involuntary twitching, clumsiness, chorea (jerky movements), and personality changes.
Technology and Brain Study

Early knowledge of brain function came from studying the brains of people with brain diseases or injury. Brain damage causes symptoms such as loss of particular body functions or changes in behaviour. Scientists believed that the area of the brain which was abnormal must control whatever body function was changed. What would be some of the reasons for scientists to be reluctant to study the human brain? It is mainly ethical reasons in early days of brain study — (not probe healthy human brains).

Modern methods

(1) EEG (electroencephalograph)

Invented in 1924 by Dr. Hans Borger. EEG measures the electrical activity of the functioning brain and allows doctors to diagnose disorders such as epilepsy and locate brain tumours. It is also used during sleep to study sleeping disorders.

(2) Electrical stimulation of brain during surgery

Used to map functions of areas of the brain. The brain has no pain receptors so surgery can be performed with anesthesia while the patient is fully awake.

(3) Computerized tomography (CAT) scans

Are a series of cross-sectional x-rays to create a computer generated three dimensional image of a part of the body.

(4) Positron emission tomography (PET) scans

Identify which area of the brain is most active when a subject performs certain tasks.

(5) Magnetic Resonance Imaging (MRI) scans

Uses large magnets, radio frequencies and computers to produce detailed images of the brain and other body structures.

Treatment of Brain Injury:

Stroke

Caused by a lack of oxygen to a portion of the brain, (usually caused by blood clot), that causes a portion of brain to die. Clot busting drugs must be given to patient within three hours, but may cause life-threatening bleeding in the brain. Aspirin may be described, (to reduce the stickiness of platelets), and thus reduce the chance of a clot forming. NOTE: If a stroke is caused by an aneurysm, (a broken blood vessel in the brain), and blood has been thinned by aspirin, the bleeding can become worse. There is no evidence to suggest that daily aspirin will prevent strokes.

1. Spinal Cord Injuries

A gene has been identified that inhibits spinal regeneration (NOGO). NOGO produces a protein that prevents neurons of the CNS from regenerating. This isolated protein is believed to prevent wild uncontrollable growth of tissue. Researchers hope that this will lead to drug therapies that will lead to damaged CNS tissue to regenerate. NOTE: 1000 neurons may be created each day even in the brains of people in their 50's and 70's. They do not arise from mitosis but from a reserve of embryonic stem cells. These stem cells are found in some parts of the brain, but do not form into specialized cells during brain development. Similar stem cells are found in bone marrow and are responsible for a wide variety of blood cells found in the body.
The Human Eye

The eye is composed of three layers.

Sclera
A thick, white outer layer that gives the eye its shape. At the front of the eye where the sclera bulges out and becomes clear is the cornea. The thin, transparent membrane which covers the cornea and is kept moist from fluid from the tear glands is the conjunctiva.

Choroid layer
This is the middle layer of the eye which absorbs light (which has not been absorbed by the sclera) and prevents internal reflection. At the front of the eye, it becomes the iris — (opens and closes to control the size of the pupil). The pupil is the opening in the center of the iris of the eye which allows light to enter the eye. The lens is the structure behind the iris that focuses light on the retina.

Retina
The inner layer of the eye is composed of two types of photoreceptors: (A) rods (more sensitive to light than cones but unable to distinguish colours) and (B) cones (require more light than cones to be stimulated but are able to detect red, green, and blue). Cones are not evenly distributed on the retina. They are concentrated in an area called the fovea centralis which is directly behind the center of the lens.

NOTE: When we are doing something that requires great detail, we move the object directly in front of our eyes to focus the image on the fovea since this area produces the most distinct image.

The eye may be looked at as having two chambers, anterior and posterior, which are divided by the lens. Anterior chamber is between the cornea and the lens and is filled with a transparent watery fluid called the aqueous humour. It is like a pre-lens which initiates the process of focusing an image on the retina before it encounters the lens. The posterior compartment is behind the lens and is filled with a clear gel called the vitreous humour and helps to maintain the shape of the eyeball.

Eye Terminology

Cornea: the clear, dome-shaped tissue covering the front of the eye.
Iris: the colored part of the eye. It controls the amount of light that enters the eye by changing the size of the pupil.
Lens: The crystalline structure located just behind the iris. It focuses light onto the retina.
Optic nerve: is the nerve that transmits electrical impulses from the retina to the brain.
Pupil: is the opening in the center of the iris. It changes size as the amount of light changes (the more light, the smaller the hole).
Retina is the sensory tissue that lines the back of the eye. It contains millions of photoreceptors (rods and cones) that convert light rays into electrical impulses that are relayed to the brain via the optic nerve.
Vitreous: is a thick, transparent liquid that fills the center of the eye. It is mostly water and gives the eye its form and shape; (also called the vitreous humour).
How the eye works

(1) Light enters the eye.
(2) It passes through the cornea, aqueous humour, pupil, lens and vitreous humour and forms an image on the retina. (If there is too much light present the pupil constricts and dilates if light is insufficient.)
(3) The retina has three cell layers (ganglion cell layer, bipolar cell layer, and the rod and cone cell layer. Bipolar cells synapse with rods and cones and transmit impulses to ganglion cells. Ganglion cells join together and form the optic nerve as they exit the eye. Optic nerve carries the impulse to the brain. Blind spot is the point where the optic nerve leaves the eye.

Eye disorders

(1) Glaucoma
A buildup of aqueous humour between the lens and the cornea. This fluid is produced continuously and has its own drainage system. If system is blocked, pressure is created and nerve fibers responsible for peripheral vision is destroyed. The damage cannot be repaired but it can be curbed with medication.

(2) Astigmatism
An abnormality in shape of cornea or lens and results in uneven focus. Corrective lens can put focused image in front of retina.

(3) Hyperopia (far-sightedness)
Where a person has difficulty seeing things close up. It is caused by the eyeball being too short or ciliary muscles being too weak to focus nearby objects on the retina.

(4) Myopia (near-sightedness)
where a person has difficulty seeing things far away. It is caused by an eyeball which is too long or ciliary muscles which are too strong.

(5) Cataracts
cloudy or opaque areas on the lens that increase over time. It tends to occur in older people and can result from exposure to sunlight. It can be repaired surgically by replacing damaged lens with artificial lens.

(6) Lazy Eye
an eye that diverges in gaze and is more formally called strabismus. A lazy eye (strabismus) can be due to either esotropia (cross-eyed) or exotropia (wall-eyed). The danger of the condition is that the brain comes to rely more on one eye than the other and that part of the brain circuitry connected to the less-favored eye fails to develop properly, leading to amblyopia (blindness) in that eye. The classic treatment for a moderately lazy eye has long been an eyepatch, covering the stronger eye with a patch, forcing the weaker eye to do enough work to catch up. However, eyedrops can work as well as an eyepatch in correcting moderate lazy eye and preventing the development of amblyopia. Atropine eyedrops are instilled daily in the stronger (dominant) eye. The atropine works by blurring rather than blocking vision in the stronger eye. Severe strabismus may require surgery. The surgery is designed to increase or decrease the tension of the small muscles outside the eye.
NOTE: Treatment — Laser surgery can correct hyperopia, myopia and astigmatism. There are two
types of Laser surgery: (A) PRK (photorefractive keratectomy) and (B) LASIK (laser in situ
keratomileusis). PRK is an outpatient procedure performed with anaesthetic eye drops. A laser beam
reshapes the cornea by cutting microscopic amounts of tissue from the outer surface of the cornea. It
takes a few minutes and recovery is very quick. LASIK is more complex and is used for all degrees
of nearsightedness. A knife is used to cut a flap of corneal tissue and laser removes tissue underneath
and cornea is replaced. Unlike PRK which is controlled by computer, LASIK depends on a surgeon's
skill. Both methods have high success rates but there are cases where eyesight may be diminished
after surgery.

Corneal Transplant: If the cornea is severely damaged (usually by disease), a transplant may be
performed. The transplants come from donors and do not have to be matched to the same extent as
livers and kidneys. Recovery time is long but most patients do well and vision usually improves in 6-
12 months. Recurrence of disease in the donor cornea is unusual.

The Human Ear

The ear is also a homeostatic organ. It has mechanoreceptors that translate movement of air into
a series of nerve impulses that the brain is able to interpret as sound. It is divided into three
separate sections: (1) outer ear; (2) middle ear; (3) inner ear.

(1) Outer ear — pinna and auditory canal: Auditory canal contains tiny hairs and sweat glands,
some of which are modified to secrete earwax that protects the ear from foreign particles.

(2) Middle ear — begins at the tympanic membrane or eardrum and ends at two small openings
called the round window and the oval window. Between the tympanic membrane and the oval
window are the three smallest bones: (a) malleus (hammer); (b) incus (anvil) and (c) stapes
(stirrup). These three bones comprise the ossicles. Between the middle ear and the nasopharynx is the auditory tube or the eustachian tube. This tube allows ear pressure to equalize, and in elevators and airplanes, yawning can cause the air to move
through the eustachian tube and the ear will “pop”.

(3) Inner ear consists of three sections: (a) cochlea (involved in hearing); (b) vestibule (balance and
equilibrium); (c) semicircular canals (balance and equilibrium). The inner ear is filled with fluid,
whereas the outer and middle ear contain air.

How we hear:
(1) Sound waves enter the auditory canal.
(2) Sound waves cause the tympanic membrane to vibrate.
(3) These vibrations pass across the tympanic membrane to the malleus, which causes the incus and
the stapes to move.
(4) The stapes passes the vibration to the membrane of the oval window, which passes it through to
the fluid within the cochlea.
(5) The cochlea contains three canals: vestibular, cochlear and tympanic. (i) Vestibular canal joins
the tympanic canal and leads to the round window. (ii) Lower wall of the cochlear canal is formed
from the basilar membrane. (iii) Basilar membrane has tiny hair cells which connect to the tectorial
membrane.
Hair cells in the cochlear canal combine to form the spiral organ, or the organ of Corti and synapse with fibres from the cochlear or auditory nerve.

**Ear Disorders**

**I Nerve deafness** is caused by damage to hair cells in the spiral organ. Hearing loss is usually uneven, with some frequencies more affected than others. It usually happens with aging and cannot usually be reversed.

**II Conduction deafness** is caused by damage to outer or middle ear that affects the transmission of sound waves to the inner ear. It can be improved with hearing aids.

**Treatments**

1. **Hearing Aids**:
   (A) Conventional use a microphone to gather sound, an amplifier to increase the sound, and a receiver to transmit the sound to the inner ear. The volume is adjustable by user.
   
   (B) Programmable have an analog circuit that healthcare professional can program for an individual’s needs. It has automatic volume control and sound is processed digitally. Individuals differ in hearing loss at different frequencies so different frequencies require different amounts of amplification. It can be tailored to the individual.

2. **Eustachian Tube Implants**:
   Children can get a fluid build-up behind the eardrum which causes chronic middle ear infection; (due to shallow angle between eustachian tube and middle ear and proper fluid drainage does not occur). A common solution is typanostomy tube surgery or eustachian tube implants. The tubes are laced in tiny slit in the eardrum relieving pressure from built-up fluid and allowing fluid to drain. It is simple surgery, rarely with complications. The tubes are usually pushed out as eardrum heals (6 months to 2 years).

**Ethical issues for auditory and visual disorders**:
(1) Surgery may exclude a person from the deaf community that communicates in sign language.
(2) There are few donor cornea available for transplant. Should there be mandatory donation?