Maintaining Dynamic Equilibrium II

Chapter 12: The Nervous System

Introduction

- ✓ Of all the organisms on Earth, humans have the most complex nervous system.
- ✓ This is the result of millions of years of evolution.
- ✓ The evolution of the more complex vertebrate brain exhibits a number of trends ;

  1. The ratio of the brain to body mass increases.
  2. There is a progressive increase in the size of the area of the brain, called the **cerebrum**, which is involved in higher mental abilities.

- ✓ Over the past two million years, the human brain has doubled in size.

12.1 - The Structure of the Nervous System

- ✓ The human nervous system is very important in helping to maintain the homeostasis (balance) of the human body.
- ✓ The human nervous system is a high speed communication system to and from the entire body.
- ✓ A series of sensory receptors work with the nervous system to provide information about changes in both the internal and external environments.
- ✓ The human nervous system is a complex of interconnected systems in which larger systems are comprised of smaller subsystems each of which have specific structures with specific functions.
- ✓ There are two major parts of the human nervous system ;

  (A) Central Nervous System (CNS)
  (B) Peripheral Nervous System (PNS)

- ✓ The CNS is made up of the **brain** and **spinal cord**.
- ✓ The PNS is made up of all the **nerves** that lead into and out of the CNS.

See Fig. 12.2 , P. 392.

The Central Nervous System

- ✓ The CNS, brain and spinal cord, receives sensory information and initiates (begins) motor control.

- ✓ This system is extremely important and therefore must be well protected. Protection is provided in a variety of ways

  1. Bone provides protection in the form of a skull around the brain and vertebrae around the spinal cord.

  2. Protective membranes called meninges surround the brain and spinal cord.

  3. Cerebrospinal fluid fills the spaces between the meninges membranes to create a cushion to further protect the brain and spinal cord.

- ✓ The spinal cord extends through the vertebrae, up through the bottom of the skull, and into the base of the brain.

- ✓ The spinal cord allows the brain to communicate with the PNS.

- ✓ A cross section of the spinal cord shows that it contains a central canal which is filled with cerebrospinal fluid, and two tissues called **grey matter** and **white mater**. { See Fig. 12.4, P. 393 }

- ✓ The grey matter is made of neural tissue which contains three types of nerve cells or neurons:
  1. Sensory neurons
  2. Motor neurons
  3. Interneurons

- ✓ Grey matter is located in the center of the spinal cord in the shape of the letter H.

- ✓ The white matter of the spinal cord surrounds the grey matter. It contains bundles of interneurons called **tracts**.

The Peripheral Nervous System

- ✓ As stated before, the PNS is made up of nerves.

- ✓ The PNS is made up of two subsystems ;

  1. Autonomic Nervous System
  2. Somatic Nervous System

- ✓ The autonomic nervous system is not consciously controlled and is often called an involuntary system. It is made up of two subsystems ;

  1. Sympathetic Nervous System
  2. Parasympathetic Nervous System

- ✓ The sympathetic and parasympathetic systems control a number of organs within the body.
- ✓ The sympathetic nervous system sets off what is known as a "fight - or - flight" reaction. This prepares the body to deal with an immediate threat. Stimulation of the sympathetic nervous system causes a number of things to occur in the body:

  1. Heart rate increases
  2. Breathing rate increases
  3. Blood sugar is released from the liver to provide energy which will be needed to deal with the threat.

- ✓ The parasympathetic nervous system has an opposite effect to that of the sympathetic nervous system. When a threat has passed, the body needs to return to its normal state of rest. The parasympathetic system does this by reversing the effects above:

  1. Heart rate decreases (slows down).
  2. Breathing rate decreases (slows down).
  3. A message is sent to the liver to stop releasing blood sugar since less energy is needed by the body.

- ✓ The somatic nervous system is made up of **sensory nerves** and **motor nerves**.

- ✓ Sensory nerves carry impulses (messages) from the body's sense organs to the central nervous system.

- ✓ Motor nerves carry messages from the central nervous system to the muscles.

- ✓ To some degree, the somatic nervous system is under conscious control.

- ✓ Another function of the somatic nervous system is a reaction called a **reflex**.

Neurons & Reflex Responses

- ✓ The **neuron** or nerve cell is the structural and functional unit of the nervous system.

- ✓ Both the CNS and the PNS are made up of neurons.

- ✓ 90% of the body's neurons are found in the CNS.

- ✓ Neurons held together by connective tissue are called **nerves**.

- ✓ The nerve pathway which leads from a stimulus to a reflex action is called a **reflex arc**.

- ✓ A typical nerve cell or neuron consists of three parts ;

  1. The cell body
  2. Dendrites
  3. Axon See Fig. 12.6, P. 395

- ✓ The **cell body** is the largest part of a neuron. It has a centrally located nucleus which contains a nucleolus. It also contains cytoplasm as well as organelles such as mitochondria, lysosomes, golgi bodies, and endoplasmic reticulum.

- ✓ The **dendrites** receive signals from other neurons. The number of dendrites which a neuron has can range from 1 to 1000s depending on the function of the neuron.

- ✓ The **axon** is a long cylindrical extension of the cell body. It can range from 1mm to 1m in length. When a neuron receives a stimulus the axon transmits impulses along the length of the neuron. At the end of the axon there are specialized structures which release chemicals that stimulate other neurons or muscle cells.

- ✓ There are three types of neurons:
  1. Sensory neuron
  2. Motor neuron
  3. Interneuron

- ✓ A sensory neuron carries information from a sensory receptor to the CNS.
- ✓ A motor neuron carries information from the CNS to an effector such as a muscle or gland.
- ✓ An interneuron receives information from sensory neurons and sends it to motor neurons.
- ✓ { See Fig. 12.7, P. 396 }

The Brain & Homeostasis

- ✓ Today, scientists have a lot of information about what happens in the different parts of the brain; however they are still trying to understand how the brain functions.
- ✓ We know that the brain coordinates homeostasis inside the human body. It does this by processing information which it receives from the senses.
- ✓ The brain makes up only 2 percent of the body's weight, but can contain up to 15 percent of the body's blood supply, and uses 20 percent of the body's oxygen and glucose supply.
- ✓ The brain is made up of 100 billion neurons.
- ✓ Early knowledge of how the brain functions came from studying the brains of people who have some brain disease or brain injury.
- ✓ Today, innovations in technology have resulted in many ways of probing the structure and function of the brain. These include:

    1. The electroencephalograph (EEG) which was invented in 1924 by Dr. Hans Borger. This device measures the electrical activity of the brain and produces a printout (See Fig. 12.8, P.398). This device allows doctors to diagnose disorders such as epilepsy, locate brain tumors, and diagnose sleep disorders.

    2. Another method is direct electrical stimulation of the brain during surgery. This has been used to map the functions of the various areas of the brain. In the 1950s, Dr. Wilder Penfield, a Canadian neurosurgeon was a pioneer in this field of brain mapping

3. Advances in scanning technology allow researchers to observe changes in activity in specific areas of the brain. Scans such as computerized tomography (CAT scan), positron emission tomography (PET scan), and magnetic resonance imaging (MRI scan) increase our knowledge of both healthy and diseased brains.

    - **CAT scans** take a series of cross-sectional X-rays to create a computer generated three dimensional images of the brain and other body structures.

    - **PET scans** are used to identify which areas of the brain are most active when a subject is performing certain tasks.

    - **MRI scans** use a combination of large magnets, radio frequencies, and computers to produce images of the brain and other body structures.

<u>The Brain</u>

✓ Based on the scanning technologies above, scientists have produced a lot of information about how different parts of the brain function.

✓ The **<u>medulla oblongata</u>** is located at the base of the brain where it attaches to the spinal cord. It has a number of major functions

1. It has a cardiac center which controls a person's heart rate and the force of the heart's contractions.
2. It has a vasomotor center which is able to adjust a person's blood pressure by controlling the diameter of blood vessels.
3. It has a respiratory center which controls the rate and depth of a person's breathing.
4. It has a reflex center which controls vomiting, coughing, hiccupping, and swallowing.

Any damage to the medulla oblongata is usually fatal.

✓ The **<u>cerebellum</u>**, which is located towards the back of the brain, controls muscle co-ordination. This structure contains 50 percent of the brain's neurons. By controlling our muscle coordination, the cerebellum helps us maintain our balance.

✓ The **<u>thalamus</u>** is known as a sensory relay center. It receives the sensations of

touch, pain, heat and cold as well as information from the muscles. Mild sensations are sent to the cerebrum, the conscious part of the brain. Strong sensations are sent to the hypothalamus.

- ✓ The **hypothalamus** is the main control center for the autonomic nervous system. The hypothalamus helps the body respond to threats (stress) by sending impulses to various internal organs via the sympathetic nervous system. After the threat is passed, it helps the body to restore to its normal resting state or homeostasis.

- ✓ The **cerebrum** is the largest part of the brain. It has a number of functions:

  1. All of the information from our senses is sorted and interpreted in the cerebrum.

  2. The voluntary muscles which control movement and speech are controlled here.

  3. Memories are stored in this area.

  4. Decisions are made here.

The cerebrum is divided into two halves; these are called the **right and left hemispheres**. Each hemisphere is covered by a thin layer called the **cerebral cortex**. This cortex contains over one billion cells and it is this layer which enables us to experience sensation, voluntary movement and our conscious thought processes. The surface of the cortex is made of grey matter. The two hemispheres are joined by a layer of white matter called the **corpus callosum** which transfers impulses from one hemisphere to the other.

The cerebrum is also divided into four areas called lobes. These include:

1. Frontal lobe	3. Occipital lobe
2. Parietal lobe	4. Temporal lobe

See Fig. 12.12, P. 400

The **frontal lobe** is involved in muscle control and reasoning. It allows to think critically.

The **parietal lobe** receives sensory information from our skin and skeletal muscles. It is also associated with our sense of taste.

The **occipital lobe** receives information from our eyes.

The **temporal lobe** receives information from our ears.

Section 12.2 - **How the Neuron Works**

- ✓ Neurons are formed by the same process as other cells, however, they have special structures which allow them to perform special jobs.

- ✓ A neuron works by sending a wave of depolarization down its length via the movement of two ions, sodium (Na^+) and potassium (K^+).

The Neuron At Rest

- ✓ When a neuron is at rest, the outside of the membrane is more positive than the inside.

- ✓ On the outside of the membrane there is a high concentration of sodium ions and on the inside there is a low concentration of potassium ions. There are also negatively charged chloride ions on the outside of the membrane.

- ✓ The membrane has special channels or gates to allow sodium, potassium, and chloride ions to move back and forth across the membrane.

- ✓ At rest, the membrane is 50 times more permeable to potassium ions than to sodium ions. Thus, as sodium is moving into the cell, there is more potassium moving out of the cell. This makes the inside of the cell negative while the outside becomes positive.

- ✓ As well, a sodium / potassium pump moves sodium and potassium ions back and forth across the membrane which helps to make the outside positive and the inside negative. At rest, the difference in charge across the membrane is -70 mV, this is called the **resting potential** of the neuron.

The All-or-None Principle

- ✓ Sensory neurons are stimulated by several different sources ;

  1. Chemicals
  2. Light
  3. Heat
  4. Electrical current

- ✓ In order for the neuron to send a wave of depolarization down its axon, the stimulus must be at a certain level. If the stimulus does not reach this level, no message is sent. This is called the **all-or-none principle**.

Depolarization

- ✓ When a neuron is sufficiently stimulated, a wave of depolarization is produced.
- ✓ This causes the sodium and potassium gates in the membrane to open. The positively charged sodium ions move into the cell and neutralize the negative charges which are inside. The outside of the membrane now becomes negative while the inside becomes positive. This change in charge is called the **action potential**.
- ✓ The action potential continues to flip-flop down the length of the axon allowing the impulse or message to travel down the neuron.

Repolarization

- ✓ As the impulse moves down the axon, the membrane of the neuron becomes repolarized ; positive outside and negative inside. This occurs because positively charged sodium and potassium ions move out of the cell.
- ✓ The process of repolarization occurs very quickly, thus a neuron can fire many impulses along its length every second.
- ✓ Between impulses the neuron goes into a brief resting state which is called the **refractory period**. This lasts for only about 0.001 s.
- ✓ The impulse or wave of depolarization travels at different speeds depending on the neuron in which it occurs.
- ✓ Neurons which need to fire impulses at fast speeds have a fatty layer called the **myelin sheath** which is formed by special cells called **Schwann cells** wrapping themselves around the axon of the neuron.
- ✓ Between the Schwann cells is a gap called the **node of Ranvier.** When a nerve impulse travels down an axon with a myelin sheath, the impulse jumps from one node to the next. This jumping can allow an impulse to speed up from a normal 2 m/s to 120 m/s.
- ✓ Neurons which have Schwann cells have the ability to regenerate themselves after they are damaged. However, if the damage is very severe, they are unable to repair themselves.

- ✓ In the CNS, brain and spinal cord, damaged neurons are unable to regenerate themselves. In the brain, the function of the damaged area can be taken over by another area of the brain, however, damage to the spinal cord is usually permanent.

- ✓ Lack of oxygen to a part of the brain is the result of a stroke and this causes that portion of the brain to die. Treatment for stroke involves the use of clot-busting drugs which must be taken within a three hour interval after the stroke occurs.

- ✓ Some patients will experience life-threatening bleeding in the brain some strokes are caused by an aneurysm where a blood vessel breaks in the brain.

- ✓ It is thought that aspirin will prevent a stroke. This is not true, in fact aspirin may cause a bigger problem because it thins the blood and thus causes more bleeding.

- ✓ Repair of the brain and spinal cord is a major area of research. A gene called Nogo has been found, this gene inhibits spinal regeneration. It is hoped that drug therapies will be produced to enable the damaged CNS to regenerate itself.

- ✓ It is estimated that up to 1000 new neurons may be created each day in a person's brain. These are produced from embryonic stem cells which remain in an individuals body. These stem cells are found in the brain of an individual as well as in the bone marrow.

The Synapse

- ✓ Neurons that work together to send impulses do not touch each other, rather there are tiny gaps between them called **synapses**.

- ✓ A neuron which carries a stimulus or wave of depolarization towards a synapse is called a **presynaptic neuron** while the neuron which receives a stimulus after it crosses a synapse is called a **postsynaptic neuron**.

- ✓ When a stimulus reaches the end of a neuron it triggers the opening of calcium ion gates. Once released, the calcium triggers the release of special chemicals called **neurotransmitters**. The neurotransmitters are released from structures called **synaptic vesicles**. The neurotransmitter is released into the synapse and travels to the dendrites of the postsynaptic neuron where it will either excite or inhibit the neuron.

- ✓ If the neuron becomes excited we call this an **excitatory response** and the

stimulus continues down the next neuron. However, if the neuron is inhibited, the stimulus stops and no message is sent down the neuron.

- ✓ As well as stimulating other neurons, neurotransmitters can also stimulate muscles and glands. In muscles, neurotransmitters cause them to contract and move while in glands neurotransmitters trigger the release of hormones into the blood.

- ✓ Neurotransmitters which are released into the synapse are broken down by enzymes which are released by the presynaptic neuron immediately after their job is finished. For example, cholinesterase is the enzyme which breaks down the neurotransmitter acetylcholine.

- ✓ Other neurotransmitters of the nervous system include;

  1. Noradrenaline (norepinephrine)
  2. Glutamate
  3. Gamma aminobutyric acid (GABA)
  4. Dopamine
  5. Seratonin

- ✓ Noradrenaline is the primary (main) neurtransmitter of the sympathetic nervous system.

- ✓ Glutamate account for 75 percent of all the excitatory transmissions of the cerebral cortex.

- ✓ GABA is the most common inhibitory neurotransmitter in the brain.

- ✓ Dopamine elevates mood and controls skeletal muscles.

- ✓ Serotonin is involved in alertness, sleepiness, thermo-regulation, and mood.

- ✓ Drugs such as valium and Prozac have been developed to stimulate or inhibit certain neurotransmitters.

<u>Disorders of the Nervous System</u>

- ✓ The nervous system controls or affects every action and thought which we have. However, there are numerous disorders of the system some of which include ;

  1. Multiple sclerosis
  2. Alzheimers

3. Parkinsons
4. Meningitis

✓ Multiple sclerosis, also called MS, affects the nerve cells in the brain and spinal cord. This disorder causes the myelin sheath which surrounds the nerve cells to become inflamed or damaged, disrupting nerve impulses. Disruption of the nerve impulses can cause a variety of symptoms including;

1. Blurred or double vision
2. Slurred speech
3. Loss of coordination
4. Muscle weakness
5. Tingling and numbness in the arms and legs
6. Seizures

There is no cure for MS at this time, but it can be treated through the use of certain medications.

✓ Alzheimers is a form of dementia. This means that it is an impairment of the brain's intellectual functions such as memory and orientation. It is caused by deposits of a protein called amyloid on the communication paths between brain cells. Symptoms include:

1. Memory loss
2. Confusion
3. Impaired judgment
4. Impairment of the ability to communicate
5. Changes in personality such as becoming irritable, anxious, delusional, and aggression.

- There is no way to prevent this disease and treatment is limited. It is an irreversible illness where mental ability declines over a 3 to 20 year period.

- Parkinson's disease is a disorder which is caused by the death of the neurons which produce a chemical called dopamine. Dopamine is a chemical which carries messages between the areas of the brain that control body movements. Early symptoms of Parkinson's are slight tremors and stiffness in the on one side of the body. As the disease progresses, the tremors spread to both sides of the body, the limbs become rigid, body movements slow, and an abnormal gait (walk) occurs.

  There is no cure for Parkinson's, but the individual symptoms can be treated with medications that either boost the dopamine levels or mimic the effect of dopamine on target brain cells. Long term use of these medications can lead to mental impairment. Surgery may be performed where electrodes are implanted into the specific brain areas

where Parkinson's is most active, however this treatment is not completely effective.

- ✓ Meningitis is caused by a viral or bacterial infection of the meninges membranes which surround the brain and spinal cord. Viral meningitis is common in children and usually clears up in 7 to 10 days. Bacterial meningitis can be fatal if not treated immediately. Symptoms of meningitis include ;

1. Headache
2. Fever
3. Stiff neck
4. Sensitivity to light
5. Vomiting
6. Drowsiness

- Meningitis is diagnosed by performing a spinal tap or lumbar puncture. In this procedure cerebrospinal fluid is removed and examined for the presence of bacteria or evidence of immune system activity. Prevention of meningitis involves:

1. Reducing your risk of catching bacteria or viruses from other people.
2. Washing your hands often.
3. Obtaining vaccines for bacterial meningitis. There is a 10% fatality rate for people who contract meningitis.

- ✓ Another common disorder of the nervous system is Huntington's disease. This is a fatal disorder in which nerve cells in certain parts of the brain degenerate. The degeneration causes a decrease in mental and emotional abilities and loss of control over major muscle movements. Parents with this disease have a 50% chance of passing it on to their child.

There is no cure for Huntington's disease and no form of treatment. Symptoms include:

1. Memory loss
2. Dementia
3. Involuntary twitching
4. Clumsiness
5. Personality changes

The symptoms usually progress for around a 15 year period until death occurs.

- ✓ Drugs can be used to strongly affect the nervous system. Drugs which are used on the nervous system are of two types: depressants or stimulants.

- ✓ Depressants will slow down the CNS so that an individual will feel relaxed and experience less pain, but will also experience reduced coordination and judgement. Examples of depressants are:

  1. Alcohol
  2. Opiate drugs such as heroin and morphine
  3. Tranquilizers such as valium

- ✓ Stimulants speed up the CNS so that an individual will feel an increase in energy and confidence, but may feel paranoid. Examples of stimulants are ;

  1. Caffeine
  2. Cocaine
  3. Ecstasy
  4. Nicotine

- ✓ Anaesthetic drugs can also affect the CNS. There are two types ; local and general. A local anaesthetic will numb a small area of the body by blocking the passage of nerve impulses from the skin to the brain. A general anaesthetic is used during surgery to prevent a patient from feeling pain. A general anaesthetic reduces the activity of brain cells.

Section 12.3 – **The Sense Organs**

- ✓ The human body gathers information from the outside world by using the five senses of:
  1. Sight
  2. Hearing
  3. Taste
  4. Smell
  5. Touch

- ✓ This information is essential in helping the body maintain homeostasis.

- ✓ Two of the sense organs which help us receive this information are the human eye and ear.

The Human Eye

- ✓ Humans receive a lot of information through their eyes.

- ✓ Our eyes are very important and therefore are protected by a number of things ;

1. Eyelashes
2. Eyelids
3. Eyebrows
4. Ridges of bone in the skull

✓ The eye is made up of three layers ;

1. Choroid
2. Sclera
3. Retina

✓ The **sclera** is the thick, white, outer layer which gives the eye its shape. It bulges at the front of the eye to form the **cornea**.

✓ The cornea is covered by a thin, transparent membrane called the **conjunctiva**.

✓ The middle layer of the eye is the **choroid**. It absorbs light and prevents internal reflection. At the front of the eye the choroid layer forms the **iris**. The iris opens and closes to control the size of the **pupil**.

✓ The choroid also forms a structure called the **ciliary body**. This muscular structure controls the shape of the **lens**.

✓ The inner layer of the eye is the **retina**. The retina contains two structures called photoreceptors. These are the **rods** and **cones** and they capture light. Rods are unable to distinguish colors, therefore they work well in dim light. Cones are able to detect colors such as red, green, and blue and work well in situations where there is more light.

✓ There are two chambers in the eye. In front of the lens the anterior compartment is filled with a fluid called the **aqueous humour**. Behind the lens is the posterior chamber which is filled with a fluid called the **vitreous humour**.

✓ Aqueous humour helps to focus an image and vitreous humour helps to give the eyeball its shape.

See Fig. 12.19, P. 410

How The Eye Functions

- ✓ Light entering the eye first passes through the cornea.

- ✓ Next, the light passes through the pupil. The pupil will dilate or open if there is not enough light entering the eye. On the other hand, the pupil will constrict or close if there is too much light.

- ✓ Next, the light passes through the lens. The shape of the lens can change depending on your distance from an object. When you look at something far away the lens flattens and when you look at something close the lens becomes more rounded. This adjustment of the lens is called **accommodation**.

- ✓ After it passes through the lens, the light is focussed on the retina. The retina has three layers ;
    1. The ganglion cell layer
    2. The bipolar cell layer
    3. The rod and cone cell layer

- ✓ The bipolar cells synapse or join with the rods and cones to transmit impulses to the ganglion cells. The ganglion cells join together to form the **optic nerve**. The optic nerve carries the impulse to the brain to be interpreted.

- ✓ The retina contains approximately 150 million rod cells and 6 billion cone cells. Both rods and cones use a purple pigment called **rhodopsin** to perform their job.

- ✓ The cones are concentrated in an area of the retina called the **fovea centralis**. Rods are located all over the retina.

Disorders of the Visual System

- ✓ There are a number of disorders which affect the human eye. These include ;
    1. Cataracts
    2. Glaucoma
    3. Myopia (Near-sightedness)
    4. Hyperopia (Far-sightedness)
    5. Astigmatism

- ✓ Cataracts are cloudy or opaque areas on the lens which increase over time and can eventually cause blindness. They are common in older people and can result from too much exposure to sunlight. They can be treated surgically by replacing the damaged lens with an artificial lens.

- ✓ Glaucoma is caused by too much aqueous humour building up between the lens and the cornea. Normally, excess aqueous humour is drained from this area, however, if the drainage ducts become blocked the extra fluid causes pressure which destroys the nerve fibers that control peripheral vision. The damage cannot be repaired, but can be curbed by drug treatment or surgery.

- ✓ Myopia or near-sightedness is a condition in which a person has trouble seeing objects which are far away. It is caused by the eyeball being too long or the ciliary muscles being too strong and causing the lens to become distorted.

- ✓ Hyperopia or far-sightedness is a condition in which a person has difficulty in seeing objects which are close. It is caused by the eyeball being too short or the ciliary muscles being too weak and therefore unable to focus the lens properly. Thus, images of nearby objects cannot be focused on the retina.

- ✓ An astigmatism is an abnormality in the shape of the cornea or lens which results in an uneven focus. The image is focused in front of the retina and cannot be seen correctly. Corrective lenses are used to focus the image onto the retina so that it can be seen correctly.

- ✓ Laser surgery can be performed to correct disorders such as myopia, hyperopia, and astigmatism. There are two main types of laser surgery ;
  1. Photorefractive keratectomy (PRK) surgery
  2. Laser in situ keratomileusis (LASIK) surgery

  - ✓ PRK is performed with anaesthetic eye drops. A laser beam reshapes the cornea by cutting microscopic amounts of tissue from the outer surface of the cornea. The procedure takes only a few minutes and recovery is quick.

  - ✓ LASIK is performed for people who are near-sighted. First a knife is used to cut a flap of corneal tissue, then a laser is used to remove the tissue underneath the flap and then the flap is replaced.

  - ✓ If the cornea is seriously impaired by disease, a corneal transplant can be performed. Here a diseased cornea is removed and replaced by a healthy donor cornea. Recovery is long and vision improves over 6 to 12 months.

The Human Ear

- ✓ The human ear contains mechanoreceptors. These structures are able translate the movement of air into nerve impulses which are interpreted by the brain.

- ✓ The ear has three sections:
  1. The outer ear
  2. The middle ear
  3. The inner ear

- ✓ The outer ear is made up of two parts: the **pinna** and the **auditory canal**. The pinna catches the sound and sends it down the auditory canal which contains tiny hairs and sweat glands. The auditory canal carries the sound to the **eardrum or tympanic membrane**.

- ✓ The middle ear begins at the **tympanic membrane**. It ends at two small openings called the **round window** and **oval window**. There are three small bones between the eardrum and the oval window, these are the **malleus** (hammer), **incus** (anvil), and **stapes** (stirrup). These three bones are collectively called the **ossicles**. Connected to the middle ear is a tube called the **auditory tube** or **eustachian tube**. This tube is used to equalize air pressure within the ear.

- ✓ The inner ear is made up of three sections ;

  1. Cochlea
  2. Vestibule
  3. Semicircular canals

The **cochlea** plays a role in hearing. The **vestibule** and semicircular canals are involved in balance and equilibrium.

- ✓ The process of hearing begins when sound waves are caught by the pinna and enter the auditory canal. At the end of the auditory canal, the sound waves cause the eardrum (tympanic membrane) to vibrate. Vibration of the eardrum causes the three earbones (ossicles) to vibrate. The malleus strikes the incus and the incus causes the stapes to move. The movement of the stapes causes the oval window to vibrate and this vibration passes to the cochlea and passes through the cochlear fluid. The cochlea contains three canals ; **vestibular canal**, **cochlear canal**, and **tympanic canal**. The lower wall of the cochlea is made up of a **basilar membrane**. This membrane has many tiny hair cells. These hair cells combine to form a spiral organ called the **organ of Corti**. These hairs join with the **cochlear nerve** which connects with the **auditory nerve**. The auditory nerve sends the impulse to the brain to be interpreted.

Disorders of the Auditory System

- ✓ A disorder of the auditory system will result in some form of deafness.

- ✓ There are two main types of deafness ;

  1. Nerve deafness
  2. Conduction deafness

- ✓ Nerve deafness is caused by damage to the hair cells in the spiral organ (Cochlea). It is an uneven deafness in which you can hear some frequencies better than others. It is irreversible.

- ✓ Conduction deafness is caused by damage to the outer or middle ear. It affects the transmission of sound waves to the outer ear. People who have this type of deafness are not totally deaf. This type of deafness can be improved by using a hearing aid.

- ✓ Hearing aids are of three main types ;

  1. Conventional
  2. Programmable
  3. Digital

- ✓ A conventional hearing aid has a microphone to receive the sound, an amplifier to increase the volume of the sound, and a receiver which transmits the sound to the inner ear.

- ✓ A programmable hearing aid has an analog circuit which is programmed by a health care professional. It also has automatic volume control.

- ✓ A digital hearing aid processes sound digitally. The digital hearing aid can change the pitch and frequency of a sound wave to meet an individual's needs.

- ✓ Another problem which many children face with regards to their hearing is fluid build-up behind the eardrum. This causes chronic middle ear infections. This is caused by an improperly angled eustachian tube which prevents proper fluid drainage. It can be corrected by tympanostomy or tube surgery, a procedure in which plastic tubes are placed in a slit in the eardrum. The tube allows for the fluid to drain and this relieves pressure on the eardrum. As the eardrum heals, the tube is usually pushed out of the ear. This takes about 6 months to 2 years.