UNIT V NERVOUS AND SENSORY SYSTEM

Structure and function of nervous tissue – Brain and spinal cord – Functions of CNS – Nerve conduction and synapse – Reflex action – Somatic and Autonomic Nervous system. Physiology of Vision, Hearing, Integumentary, Olfactory systems. Taste buds.

Cells are the structural and functional units of living organisms. They carry out basic functionalities of our body. A cluster of these specialized cells functions together to form a tissue. Plants and animals have different tissues. In animals, there are four types of tissues namely:

- Connective Tissue
- Epithelial Tissue
- Muscular tissue
- Nervous Tissue

Nervous Tissue

Nervous or the nerve tissue is the main tissue of our nervous system. It monitors and regulates the functions of the body. Nervous tissue consists of two cells: nerve cells or neurons and glial cells, which helps transmit nerve impulses and also provides nutrients to neurons. Brain, Spinal Cord, and nerves are composed of nervous tissue, they are specialized for being stimulated to transmit stimulus from one to another part of the body rapidly. Nervous tissue is found in the brain, spinal cord, and nerves. It is responsible for coordinating and controlling many body activities. It stimulates muscle contraction, creates an awareness of the environment, and plays a major role in emotions, memory, and reasoning. To do all these things, cells in nervous tissue need to be able to communicate with each other by way of electrical nerve impulses. The cells in nervous tissue that generate and conduct impulses are called neurons or nerve cells. These cells have three principal parts: the dendrites, the cell body, and one axon. The main part of the cell, the part that carries on the general functions, is the cell body. Dendrites are extensions, or processes, of the cytoplasm that carry impulses to the cell body. An extension or process called an axon carries impulses away from the cell body.

Nervous tissue also includes cells that do not transmit impulses, but instead support the activities of the neurons. These are the glial cells (neuroglial cells), together termed the neuroglia. Supporting, or glia, cells bind neurons together and insulate the neurons. Some are phagocytic and protect against bacterial invasion, while others provide nutrients by binding blood vessels to the neurons.

Structure Of Nervous Tissue

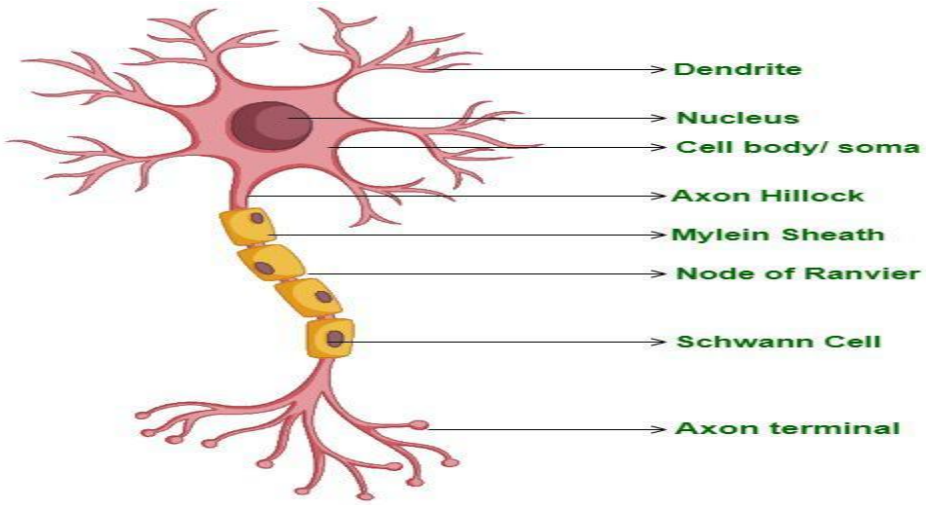
- It is made of nerve cells or neurons, all of which consists of an axon. Axons are long stem-like projections emerging out of the cell, responsible for communicating with other cells called the Target cells, thereby passing impulses
- The main part is the cell body which contains the nucleus, cytoplasm and cell organelles. Extensions of the cell membrane are referred to as processes.
- Dendrite is a highly branched processes, responsible for receiving information from other neurons and synapses (specialized point of contact). Information of other neurons is provided by dendrites to connect with its cell body.
- Information in a neuron is unidirectional as it passes through neurons from dendrites, across the cell body down the axon.

Nervous Tissue Location

The nerve tissue or the nervous tissue is the chief tissue component of the two major parts of the nervous tissue – Central nervous system(CNS) formed by the spinal cord and the brain and the branching peripheral nerves of the peripheral nervous system (PNS) that control and regulate the functions of the body and their activities.

The nervous tissue is located in the peripheral nerves all through the body and also in the organs of the central nervous system such as the spinal cord and the brain. The nervous tissue consists of the nerve cells or the neurons. Neurons are specialized cells that react to stimuli by generating signals through the axons, which are elongated structures arising from the cell body.

Nervous Tissue Diagram



Characteristics Of Nervous Tissue

- Nervous tissue makes up for the CNS and PNS of the nervous system
- Contains two distinct cells – neurons and glial cells
- It consists of the dendrites, cell body, axon and nerve endings.
- Neurons secrete chemical neurotransmitters which are responsible for stimulating other neurons as a result of a stimuli
- Presence of specialization at axonal terminals called synapsis
- Nerve cells live long, cannot be divided and replaced(except memory cells)

Function Of Nervous Tissue

- Neurons generate and carry out nerve impulses. They produce electrical signals that are transmitted across distances, they do so by secreting chemical neurotransmitters.
- Responds to stimuli
- Carries out communication and integration
- Provides electrical insulations to nerve cells and removes debris
- Carries messages from other neurons to the cell body

Types Of Nerves

The signals that are generated and initiated in the CNS(central nervous system) which typically arise from the brain and in some cases, the spinal cord, approach the outer edge to sites, for instance, the internal organs or limbs which conduct the specified organ of interest to take appropriate action. Responding to the nerve impulses, suitable actions take place such as contraction of a bicep muscle, retracting your hands from a hot cup of tea, the hair on your arms may raise due to extremely cold conditions, responding to light striking the retina, when one of the sense organs receive an input that may cause danger, etc.

The functioning of the nerves is brought about by channelling electrochemical signals or impulses that are obtained from the other nerves or brain or tissues or organs at which the nerves end. On the basis of functionality, nerves can be classified into the following:

Motor nerves

Motor neurons or motor nerves are responsible to send signals or impulses all the way from spinal cord and brain to all the muscles of the body. The impulse enables humans to carry out basic activities such as talking, walking, drinking water, blinking eyes, sitting, sleeping, etc. Damage to the motor neurons can cause muscle weakness or shrinking of the muscles. The nerve that passes from the lower back to the buttocks is known as the sciatic nerve.

The sciatic nerve enables the complete leg to move which is a collection of various nerves. A few of these motor nerves function in the hamstring, feet, thighs, and feet.

Sensory nerves

The sensory nerves or sensory neurons are responsible to generate impulses or signals in the contrasting directions from another type of nerves known as the motor neurons. The sense neurons gather information such as pressure, pain, temperature, etc from the sensors that are present in the muscles, skin and other internal organs which in turn redirect it back to the brain and spinal cord. These sensory nerves have the potential of communicating information relating to motion (except for the eyes, as they themselves do it). Damage to the sensory nerves can cause numbness, pain, tingling sensation and hypersensitivity.

Autonomic nerves

The autonomic nerves system controls the actions of the muscles of the heart, such smooth muscles located in the stomach and in the interlining of glands and other organs. The autonomic nerves regulate the functions that are not under control, i.e., involuntary. There are two functional divisions in the autonomic nervous system, namely:

1. The sympathetic nervous system – Responsible for the heart rate to speed up and related flight or fight responses
2. The parasympathetic nervous system – Controls activities such as excretion, digestion, and related metabolic actions.

Cranial nerves

There are 12 pairs of cranial nerves that emerge from the lower side of the brain. Listed below are the cranial nerves mentioned from front to back:

- Olfactory
- Optic
- Oculomotor
- Trochlear
- Trigeminal
- Abducens
- Facial
- Vestibulocochlear
- Glossopharyngeal
- Vagus
- Spinal accessory

- Hypoglossal nerves

The cranial nerves are crucial in smell, vision, movement of the face and eyes, movements of the tongue and salivation.

Central Nervous System: brain and spinal cord

Our bodies couldn't operate without the nervous system - the complex network that coordinates our actions, reflexes, and sensations. Broadly speaking, the nervous system is organised into two main parts, the central nervous system (CNS) and the peripheral nervous system (PNS).

The CNS is the processing centre of the body and consists of the brain and the spinal cord. Both of these are protected by three layers of membranes known as meninges. For further protection, the brain is encased within the hard bones of the skull, while the spinal cord is protected with the bony vertebrae of our backbones. A third form of protection is cerebrospinal fluid, which provides a buffer that limits impact between the brain and skull or between spinal cord and vertebrae.

Grey and white matter

In terms of tissue, the CNS is divided into grey matter and white matter. Grey matter comprises neuron cell bodies and their dendrites, glial cells, and capillaries. Because of the abundant blood supply of this tissue, it's actually more pink-coloured than grey.

In the brain, grey matter is mainly found in the outer layers, while in the spinal cord it forms the core 'butterfly' shape.

White matter refers to the areas of the CNS which host the majority of axons, the long cords that extend from neurons. Most axons are coated in myelin - a white, fatty insulating cover that helps nerve signals travel quickly and reliably. In the brain, white matter is buried under the grey surface, carrying signals across different parts of the brain. In the spinal cord, white matter is the external layer surrounding the grey core.

The brain

The brain is a complex organ made up of specialized nerve and supportive tissues. It's surrounded by many bones that together form the skull. The part of the skull where the brain sits is called the cranium. The base, or lower part, of the brain is connected to the spinal cord. Together, the brain and spinal cord are known as the central nervous system (CNS). Many nerves send electrical signals to and from the brain and spinal cord.

Structure and function of the brain

The brain is the body's control centre. It constantly receives and interprets nerve signals from the body and sends new signals based on this information. Different parts of the brain control movement, speech, emotions, consciousness and internal body functions, such as heart rate, breathing and body temperature.

The brain has 3 main parts: cerebrum, cerebellum and brain stem.

Diagram of the central nervous system

Types of cells in the brain

The brain is made up of 2 main types of cells:

Nerve cells (neurons) are cells that carry the electrical signals that make the nervous system work. They cannot be replaced or repaired if they are damaged. They are the longest cells in the body.

Diagram of the structure of a neuron

Glial cells (neuroglial cells) are cells that support, feed and protect the nerve cells. The different types of glial cells are:

- astrocytes
- oligodendrocytes
- ependymal cells
- microglial cells

Cerebrum

The cerebrum is the largest part of the brain. It is divided into 2 halves called the left and right cerebral hemispheres. The 2 hemispheres are connected by a bridge of nerve fibres called the corpus callosum.

The right half of the cerebrum (right hemisphere) controls the left side of the body. The left half of the cerebrum (left hemisphere) controls the right side of the body.

The cerebral cortex is the outer, folded part of the brain. It is also called the grey matter. The cerebral cortex is mostly made up of the cell bodies and dendrites of nerve cells (neurons). Cell bodies contain the nucleus and other main parts of the cell. Dendrites are the short branching fibres that receive signals from other nerve cells. The inner part of the cerebrum is called the white matter. It is mostly made up of the long fibres of a nerve cell (called axons) that send signals to and from the brain to the rest of the body. The fatty coating that surrounds axons (called myelin) gives this part of the brain a whitish appearance.

If the CNS is the processing centre of the human body, the brain is its headquarters. It is broadly organised into three main regions - the forebrain, the midbrain, and the hindbrain. The largest of these three is the forebrain (derived from the prosencephalon in the developing brain). It contains the large outermost layer of the brain, the wrinkly cerebral cortex, and smaller structures towards its centre, such as the thalamus, hypothalamus, and the pineal gland.

The midbrain (derived from the mesencephalon in the developing brain) serves as the vital connection point between the forebrain and the hindbrain. It's the top part of the brainstem, which connects the brain to the spinal cord.

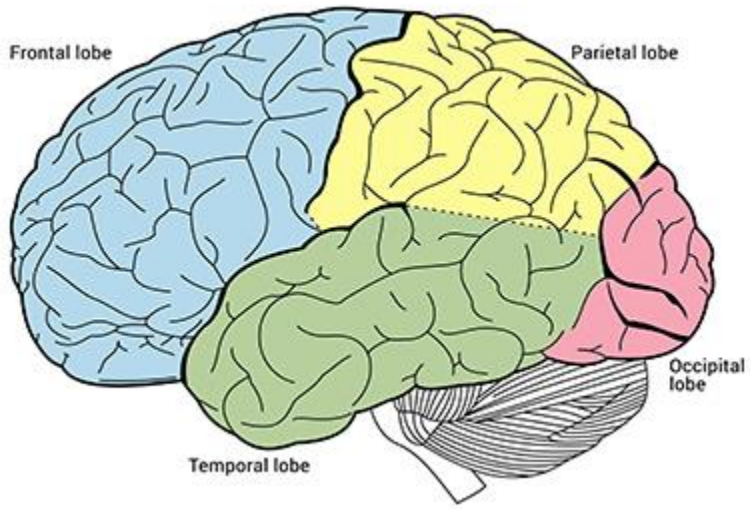
The hindbrain (derived from the rhombencephalon in the developing brain) is the lowest back portion of the brain, containing the rest of the brainstem made up of medulla oblongata and the pons, and also the cerebellum - a small ball of dense brain tissue nestled right against the back of the brainstem.

Parts of the brain

The brain's cerebral cortex is the outermost layer that gives the brain its characteristic wrinkly appearance. The cerebral cortex is divided lengthways into two cerebral hemispheres, each of which traditionally have been divided into four lobes: frontal, parietal, temporal and occipital.

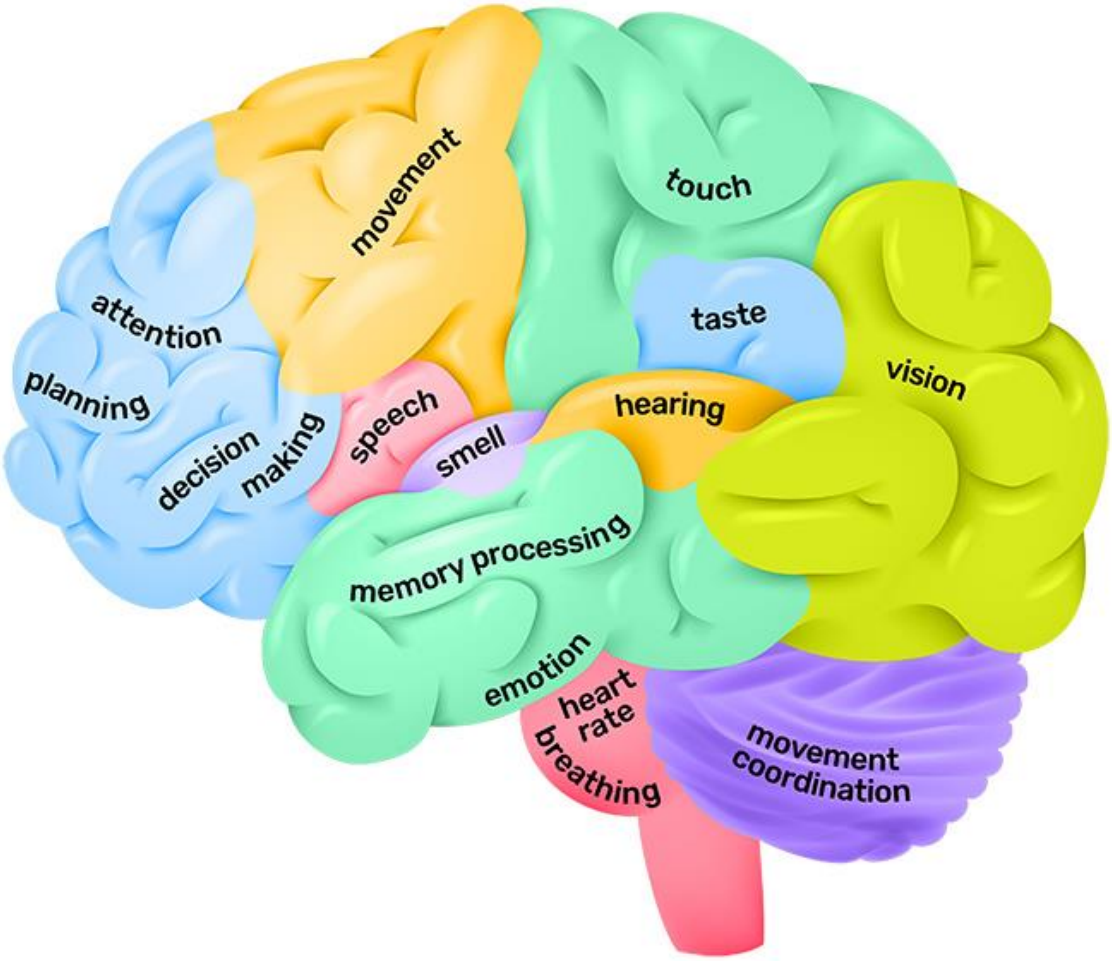
Lobes of the brain

The brain's cerebral cortex is the outermost layer that gives the brain its characteristic wrinkly appearance. The cerebral cortex is divided lengthways into two cerebral hemispheres connected by the corpus callosum. Traditionally, each of the hemispheres has been divided into four lobes: frontal, parietal, temporal and occipital.



(Wikimedia)

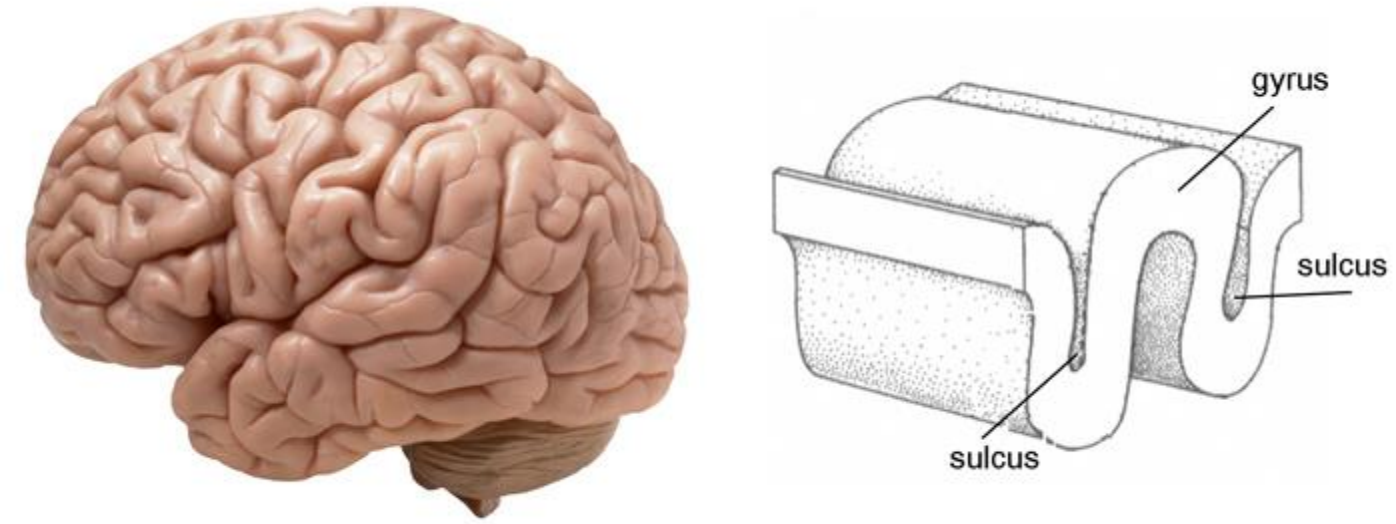
Although we now know that most brain functions rely on many different regions across the entire brain working in conjunction, it is still true that each lobe carries out the bulk of certain functions.



(QBI)

Bumps and grooves of the brain

In humans, the lobes of the brain are divided by a number of bumps and grooves. These are known as gyri (bumps) and sulci (groves or fissures). The folding of the brain, and the resulting gyri and sulci, increases its surface area and enables more cerebral cortex matter to fit inside the skull.



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Frontal lobe

The frontal lobe is separated from the parietal lobe by a space called the central sulcus, and from the temporal lobe by the lateral sulcus.

The frontal lobe is generally where higher executive functions including emotional regulation, planning, reasoning and problem solving occur. This is why in frontotemporal dementia, personality changes are often the first signs of the disease.

Parietal lobe

The parietal lobe is behind the frontal lobe, separated by the central sulcus. Areas in the parietal lobe are responsible for integrating sensory information, including touch, temperature, pressure and pain.

Because of the processing that occurs in the parietal lobe, we are able to, for example, discern from touch alone that two objects touching the skin at nearby points are distinct, rather than one object. This process is called two-point discrimination. Different areas of the body have more sensory receptors, and so are more sensitive than others in discerning distinct points. Using callipers or a folded paperclip, and asking a subject to keep their eyes closed, this test can be used to check parietal lobe function.

Temporal lobe

Separated from the frontal lobe by the lateral fissure, the temporal lobe also contains regions dedicated to processing sensory information, particularly important for hearing, recognising language, and forming memories.

Auditory information

The temporal lobe contains the primary auditory cortex, which receives auditory information from the ears and secondary areas, and processes the information so we understand what we're hearing (e.g. words, laughing, a baby crying).

Visual processing

Certain areas in the temporal lobe make sense of complex visual information including faces and scenes.

Memory

The medial (closer to the middle of the brain) temporal lobe contains the hippocampus, a region of the brain important for memory, learning and emotions.

Occipital lobe

The occipital lobe is the major visual processing centre in the brain.

The primary visual cortex, also known as V1, receives visual information from the eyes. This information is relayed to several secondary visual processing areas, which interpret depth, distance, location and the identity of seen objects.

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Cerebellum

The cerebellum is located under the cerebrum at the back of the brain. It is divided into 2 parts or hemispheres and also has grey and white matter.

The cerebellum is responsible for:

- movement
- posture
- balance
- reflexes
- complex actions (walking, talking)
- collecting sensory information from the body

Brain stem

The brain stem is a bundle of nerve tissue at the base of the brain. It connects the cerebrum and cerebellum to the spinal cord.

The brain stem has 3 areas:

- midbrain (also called the mesencephalon)
- pons
- medulla oblongata

The brain stem sends information to and from the other parts of the brain to the rest of the body and controls:

- breathing
- body temperature
- blood pressure
- heart rate
- hunger and thirst
- digestion of food

Cerebrospinal fluid (CSF)

The cerebrospinal fluid (CSF) is a clear, watery liquid that surrounds, cushions and protects the brain and spinal cord. The CSF also carries nutrients in the blood to (and removes waste products from) the brain. It circulates through chambers called ventricles and over the surface of the brain and spinal cord.

Meninges

The brain and spinal cord are covered and protected by 3 layers of tissue (membranes) called the meninges:

- dura mater – thickest outer membrane
- arachnoid layer – middle, thin membrane
- pia mater – inner, thin membrane

The CSF flows in the space between the arachnoid layer and the pia mater. This space is called the subarachnoid space.

Corpus callosum

The corpus callosum is a bundle of nerve fibres that allows communication between the 2 cerebral hemispheres. It is the largest fibre bundle in the brain.

Thalamus

The thalamus is a structure in the middle of the brain that has 2 lobes or sections. It acts as a relay station for almost all information that comes and goes between the brain and the rest of the nervous system in the body.

Hypothalamus

The hypothalamus is a small structure in the middle of the brain below the thalamus. It plays a part in controlling body temperature,

hormone

secretion, blood pressure, emotions, appetite and sleep patterns.

Pituitary gland

The pituitary gland is a small, pea-sized organ in the centre of the brain. It is attached to the hypothalamus and makes a number of different hormones that affect other glands of the body's
endocrine system

. It receives messages from the hypothalamus and releases hormones that control the thyroid and adrenal gland, as well as growth and physical and sexual development.

Pineal gland

The pineal gland is a very small gland in the third ventricle of the brain. It produces the hormone melatonin, which influences sleeping and waking patterns and sexual development.

Choroid plexus

The choroid plexus is a small organ in the ventricles that makes CSF.

Cranial nerves

There are 12 pairs of cranial nerves that perform specific functions in the head and neck, including giving us our sense of smell, sight (vision), hearing, taste, speech, feeling in the face and movement of the muscles in the face, eyes and tongue. One pair of nerves starts in specialized cells in the roof of the nose and another pair starts in the retina of the eye. The other 10 pairs start in the brain stem.

Blood-brain barrier (BBB)

The blood-brain barrier (BBB) is a specialized system of cells lining blood vessels in the brain. The BBB prevents most substances in the blood from passing into the brain and helps maintain a constant environment so the nerve cells in the brain can work properly.

The BBB is made up of very small blood vessels (capillaries) that are lined with thin, flat endothelial cells. In other parts of the body, endothelial cells have small spaces between them that allow substances to move in and out of the capillary so they can reach other cells and tissues. In the brain, the endothelial cells are packed tightly together so substances cannot pass out of the bloodstream into the brain.

Structure and function of the spine

Graphic of the spine

The spine is made up of 26 bones divided into 5 sections. These bones surround and protect the spinal cord. This includes 24 vertebrae (divided into cervical, thoracic and lumbar regions), the sacrum and the coccyx.

Cervical region – These are 7 vertebrae at the top of the spine that run from the base of the skull to the lowest part of the neck.

Thoracic region – These are 12 vertebrae that run from the shoulders to the middle of the back.

Lumbar region – These are 5 vertebrae that run from the middle of the back to the hips.

Sacrum – This is a large section of fused vertebrae at the base of the spine.

Coccyx (tail bone) – This is a small, thin section of fused vertebrae at the end of the spine.

Between the vertebrae are the discs (intervertebral discs).

Disc – A layer of cartilage found between the vertebrae. Discs cushion and protect the vertebrae and spinal cord.