Chapter: Neural Control and Coordination

Exercises

Question 1. Briefly describe the structure of the following:

(a) Brain (b) Eye (c) Ear

Answer:

a. Brain: The brain acts as a control and command system of the body. It is responsible for the protection of the skull. It is divided into three important regions such as forebrain, midbrain and hindbrain.
   i. Forebrain – It consists of three regions such as the olfactory lobes, the cerebrum and the diencephalon.
   ii. Midbrain – It is located between the thalamus/ hypothalamus of the forebrain and pons of hindbrain. The upper surface has two pairs of the rounded protrusion called the corpora quadrigemina and two bundles of fibers called the crura cerebri.
   iii. Hindbrain – It consists of the cerebellum, pons varolii and medulla oblongata .The midbrain, pons varolii and medulla oblongata are collectively called the brain stem.

b. Eye: The eyes are a hollow spherical structure composed of three coats such as the outer fibrous coat, middle vascular coat and inner nervous coat.
   i. Fibrous coat: It is thick and helps to protect the eyeball. It is of two different parts: sclera and cornea.
   ii. Vascular coat: It consists of three parts such as the choroid, iris and ciliary body.
   iii. Nervous coat: It has retina which is the neural and sensory layer of an eyeball. It contains three layers such as the ganglion cells, bipolar cells and photoreceptor cells.

c. Ear:
   i. The external ear further contains two regions such as the pinna and the external auditory canal.
   ii. The projecting elastic cartilage covered with skin is called the pinna. It is the most prominent outer ridge known as the helix.
   iii. The external auditory canal is an S-shaped tube leading inward from the pinna. It is a tubular passage supported by the cartilage in its exterior part.
   iv. The middle ear contains three small bones known as the ear ossicles- malleus, incus and the stapes. These are attached to one another and increase the efficiency of transmission of sound waves to the inner ear.

Question 2. Compare the following:

(a) Central neural system (CNS) and Peripheral neural system (PNS)

(b) Resting potential and action potential

(c) Choroid and retina

Answer:

a. CNS: Central neural system lies with the mid-dorsal axis of the body. It is a hollow in shape, dorsally placed structure and comprises brain and the spinal cord. It is also known as the centre of information processing and control.
PNS: The nerves arising from the central nervous system constitute along with the peripheral nervous system. This carries information to and from the central neural system (CNS). It consists of the spinal nerves and cranial nerves.

b. Resting potential: It is the extracellular fluid outside the plasma membrane of nerve fiber which is positively charged with respect to the cells present inside the plasma membrane. The resting nerve fiber shows a potential difference between inside and outside of this plasma membrane. This difference in the electrical charges across the plasma membrane is known as the resting potential.

Action potential: The action potential is also known as the nerve impulse. At the excited state the content present inside the cell becomes positively charged with respect to the extracellular fluid outside it. This change in polarity across the plasma membrane is called an action potential.

c. Choroid: The choroid lies at the adjacent side of the sclera and it includes numerous blood vessels that supply nutrients and oxygen to the other tissues especially of the retina. It has abundant pigment cells and is dark brown in colour.
Retina: The retina is the neural and the sensory layer of the eyeball. The retina is a very delicate coat and lines the entire vascular coat. Its external surface is in contact with the choroid and its internal surface with the vitreous humour. It includes the ganglion cells, bipolar cells and the photoreceptor cells.

Question 3. Explain the following processes:

(a) Polarisation of the membrane of a nerve fibre

(b) Depolarisation of the membrane of a nerve fibre

(c) Conduction of a nerve impulse along a nerve fibre

(d) Transmission of a nerve impulse across a chemical synapse

Answer:

(a) The polarization of the membrane of a nerve fiber: Inside the resting nerve fiber, the plasma membrane separates two solutions which have different chemical composition but the same total number of the ions. Inside the external medium the sodium ions predominate. But within the fiber the potassium ions predominate. The difference in the flow of the positively charged ions and the inability of the negatively charged ions within the nerve fiber to pass out causes an increasing positive charge on the outside of the membrane whereas the negative charge on the inside of the membrane. Due to this the membrane of the resting nerve fiber polarized, extracellular fluid outside being electropositive with respect to the cell contents inside it.
(b) The depolarization of the membrane of a nerve fiber: During the process of depolarization, the activation gates of sodium channels open whereas the potassium channels remain closed. The sodium ions rush into the axon. The entry of sodium ions leads to the process of depolarization of the nerve membrane due to this the nerve fiber contents become electropositive with respect to the extracellular fluid.
(c) The conduction of a nerve impulse along a nerve fiber: The nervous system transmits information

as a series of the nerve impulses. The movement of an action potential as a wave through a nerve fiber is known as the nerve impulse. The action potentials are propagated which means they are self-generated along with the axon. The events that help to set up an action potential at one spot on the nerve fiber are also responsible to transmit it along with the entire length of the nerve fiber. Then the action potential moves to the neighboring region of the nerve fiber till it covers the whole length of the fiber.

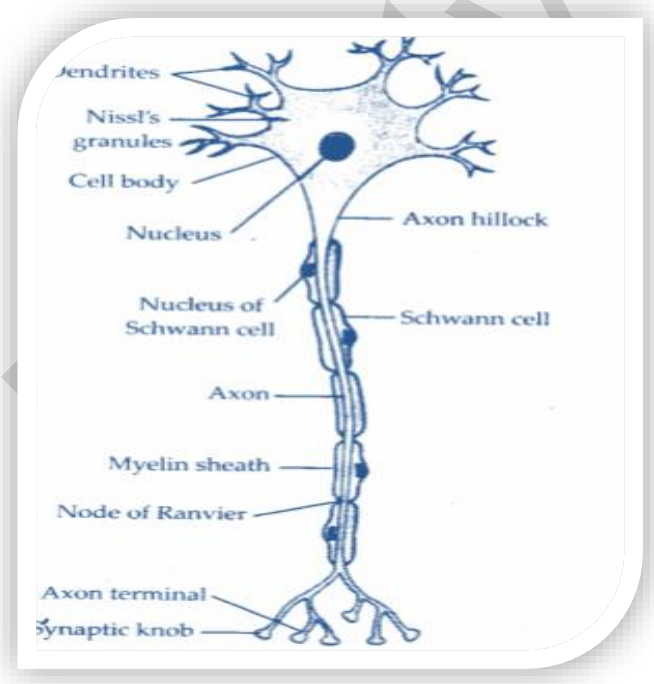
(d) The transmission of a nerve impulse across a chemical synapse: During a chemical synapse, the membranes there is a separation of the presynaptic and postsynaptic neurons with the help of a fluid-filled space known as the synaptic cleft. The neurotransmitter chemicals are involved in the transmission of impulses at these synapses. The axon terminal includes vesicles filled with these neurotransmitters. When an impulse arrives at the axon terminal, it stimulates the movement of the synaptic vesicles towards the membrane where they fuse with the plasma membrane and hence burst to release their neurotransmitters in the synaptic cleft. The released neurotransmitters bind to their specific receptors which are present on the post- synaptic membrane. This binding opens ion channels by allowing the entry of ions which can generate a new potential in the postsynaptic neuron. The new potential developed may be either excitatory or inhibitory.

Question 4. Draw labeled diagrams of the following:

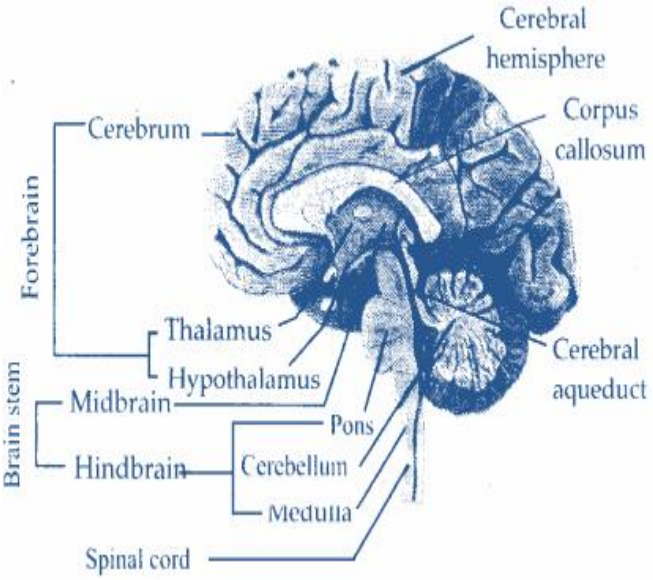
(a) Neuron (b) Brain (c) Eye (d) Ear

Answer:

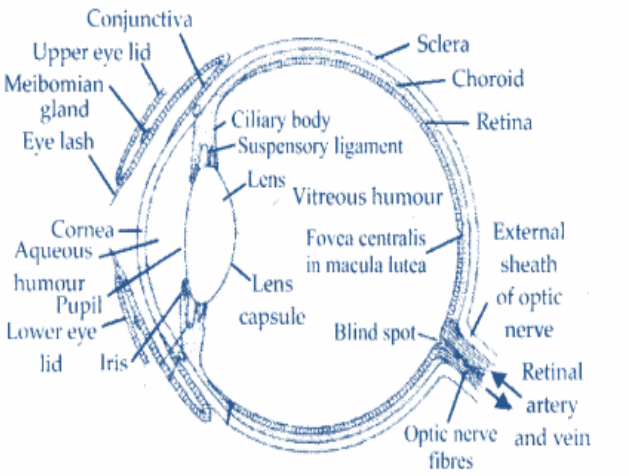
a. Neuron



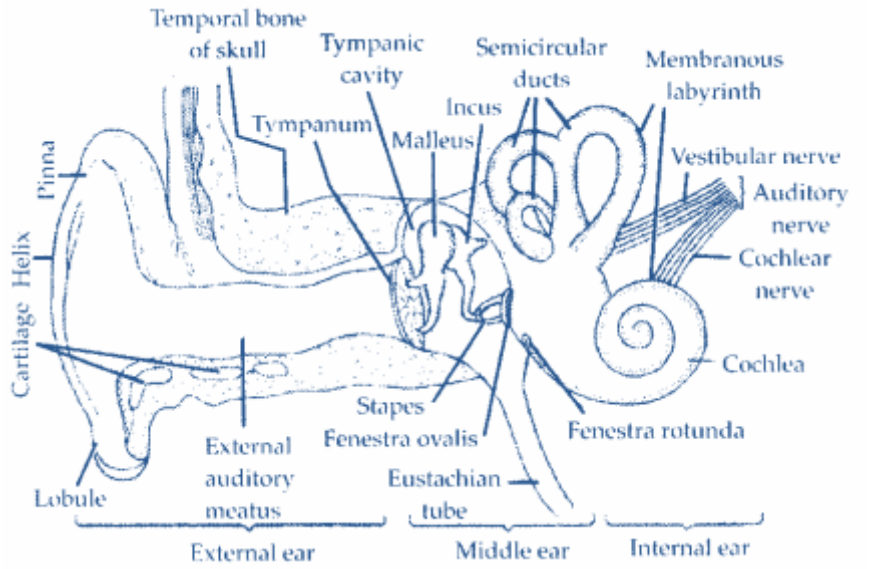
b. Brain:


Cerebral hemisphere
Corpus callosum
Cerebrum
Forebrain
Thalamus
Hypothalamus
Cerebral aqueduct
Brain stem
Midbrain
Pons
Hindbrain
Cerebellum
Medulla
Spinal cord

c. Eye:


Conjunctiva
Upper eye lid
Meibomian gland
Eye lash
Sclera
Choroid
Retina
Ciliary body
Suspensory ligament
Lens
Vitreous humour
Cornea
Aqueous humour
Pupil
Lower eye lid
Iris
Lens capsule
Fovea centralis in macula lutea
Blind spot
External sheath of optic nerve
Retinal artery and vein
Optic nerve fibres

d. Ear:


Temporal bone of skull
Tympanic cavity
Semicircular ducts
Membranous labyrinth
Incus
Tympanum
Malleus
Vestibular nerve
Auditory nerve
Pinna
Helix
Cochlear nerve
Cartilage
Cochlea
Stapes
Fenestra ovalis
Fenestra rotunda
External auditory meatus
Eustachian tube
Lobule
External ear
Middle ear
Internal ear

Question 5. Write short notes on the following:

(a) Neural coordination

(b) Forebrain

(c) Midbrain

(d) Hindbrain

(e) Retina

(f) Ear ossicles

(g) Cochlea

(h) Organ of Corti

(i) Synapse

Answer:

a. Neural coordination: When the higher animals respond to the various stimuli, each response to a specific stimulus generally involves many parts of their bodies. Hence it is necessary that all the concerned parts of the body should work in a systematic manner for the response. The working together of various parts of the body of multicellular organisms in a proper manner to complement the functions of each other is known as coordination. This is achieved by three overlapping processes of nervous system such as-sensory input, integration and motor output.

b. Forebrain: It consists of olfactory lobes which are the paired structures concerned with the sense of smell sense. The cerebrum which is the largest and most complex of all the parts of the human brain. It is divided by a cleft into left and right cerebral hemispheres which are connected by a large bundle of myelinated fibers such as the corpus and the callosum. The outer covering of the cerebral hemisphere is the cerebral cortex. It contains the sensory and the motor areas.

c. Midbrain: The midbrain is located between the pons of the hindbrain and the thalamus of the forebrain. The cerebral aqueduct passess through the midbrain canal. The dorsal portion of the midbrain consists of four round lobes known as the corpora quadrigemina. The midbrain and hindbrain are responsible for forming the brainstem.

d. Hindbrain: The hindbrain consists of pons, cerebellum and medulla. The pons are the fibre tracts that interconnect different regions of the brain. The cerebellum has a very convoluted surface in order to provide the additional space for many more neurons. The medulla of the brain is connected to the spinal cord. The medulla includes centres which control respiration, cardiovascular reflexes and gastric secretions.

e. Retina: The retina is the inner layer of an eye and it contains three layers of cells-from inside to outside – such as ganglion cells, bipolar cells and photoreceptor cells. There are two different types of photoreceptor cells, such as rods and cones. These cells contain the light-sensitive proteins known as the photopigments. The photopic vision and colour vision are

functions of cones and the scotopic vision is the function of the rods. In the human eye, three different types of cones are there which possess their own characteristic photopigments that respond to red, green and blue lights.

f. Ear ossicles : There is a small flexible chain of three small bones known as the ear ossicles – the malleus, the incus and the stapes in the middle ear. The malleus is attached to the tympanic membrane on one side and incus on the other side. The incus in turn is connected with the stapes. The malleus is the largest ossicle whereas the stapes is the smallest ossicle.

g. Cochlea : It is the main hearing organ which is connected with the saccule. It is a spirally coiled tube that resembles a snail shell in appearance. It tapers from a broad base to an almost pointed apex.

h. Organ of Corti: It is a structure located on the basilar membrane which contains hair cells that act as the auditory receptors. The hair cells are present in rows on the internal side of the organ of the corti.

i. Synapse: It is the junction between the axon of one neuron and the dendrite or cyton of another neuron for the transmission of the nerve impulse.

Question 6. Give a brief account of:

(a) Mechanism of synaptic transmission

(b) Mechanism of vision

(c) Mechanism of hearing

Answer:

a. Mechanism of synaptic transmission: The transmission of a nerve impulse across a chemical synapse: During a chemical synapse, the membranes there is a separation of the presynaptic and postsynaptic neurons with the help of a fluid- filled space known as the synaptic cleft. The neurotransmitter chemicals are involved in the transmission of impulses at these synapses. The axon terminal includes vesicles filled with these neurotransmitters. When an impulse arrives at the axon terminal, it stimulates the movement of the synaptic vesicles towards the membrane where they fuse with the plasma membrane and hence burst to release their neurotransmitters in the synaptic cleft. The released neurotransmitters bind to their specific receptors which are present on the post- synaptic membrane. This binding opens ion channels by allowing the entry of ions which can generate a new potential in the postsynaptic neuron. The new potential developed may be either excitatory or inhibitory.

b. Mechanism of vision: The light rays in visible wavelength focused on the retina through the cornea and the lens generate impulses in rods and cones. The light induces dissociation of the retinal from opsin which results in the changes of the structure of the opsin. Due to this the membrane permeability changes. Due to this the potential differences are generated in the photoreceptor cells. These are responsible to produce a signal that generates action potentials in the ganglion cells through the bipolar cells. These action impulses are transmitted by the optic nerves to the visual cortex area of

the brain, where the neural impulses are analysed and the image formed on the retina is recognized based on earlier memory and experience.

c. Mechanism of hearing: The external ear receives sound waves and directs them to the eardrum. The eardrum vibrates in response to the sound waves and these vibrations are transmitted through the ear malleus, incus and stapes to the oval window. The vibrations are passed through the oval window onto the fluid of the cochlea, where they generate waves in the lymphs. The waves present in the lymphs induce a ripple in the basilar membrane. These movements of the basilar membrane bend the hair cells by pressing them against the tectorial membrane.Due to this the nerve impulses are generated in the associated afferent neurons. These impulses are transmitted by the afferent fibers through the auditory nerves to the auditory cortex of the brain, where the impulses are analysed and the sound is recognised.

Question 7. Answer briefly:

(a) How do you perceive the colour of an object?

(b) Which part of our body helps us in maintaining the body balance?

(c) How does the eye regulate the amount of light that falls on the retina?

Answer:

a. In humans the colour vision results from the activity of cone cells is a type of photoreceptor cells. In the human eye, there are three types of cones which possess their own characteristic photopigments that respond to the red, green and blue lights. The sensations of different colours are produced by various combinations of these cones and their photopigments. When these cones are stimulated equally the sensation of white light is produced. The yellow light, for instance, stimulates green and red cones approximately to equal extent, and this is interpreted by the brain as yellow colour.

b. The ears help to maintain the balance of the body with the help of cristae and maculae present in the internal ears.

c. The iris contains two sets of smooth muscles which are sphincters and dilators. These muscles regulate the amount of light entering the eyeball by varying the size of the pupil. The contraction of the sphincter muscles makes the pupil smaller in bright light so that less light enters the eye. The contraction of the dilator muscles widens the pupil in dim light so that more light goes into the eye to fall on the retina.

Question 8. Explain the following:

(a) Role of Na+ in the generation of action potential.

(b) Mechanism of generation of light-induced impulse in the retina.

(c) Mechanism through which a sound produces a nerve impulse in the inner ear.

Answer:

a. The action potential is largely determined by Na^+ ions.

The action potential results from the sequential events which are as follows:
(i) The disturbance caused to the membrane of a nerve fiber by a stimulus results in leakage of Na^+ into the nerve fibre.
(ii) The entry of Na^+ lowers the trans-membrane potential difference.
(iii) The decrease in potential difference makes the membrane more permeable to Na^+ than to K^+ ions so that more Na^+ enter the fibre than K^+ leave it.
(iv)The accumulation of Na^+ in the nerve fibre initiates depolarisation by making the axonic contents positively charged relative to the extracellular fluid.
(v) With the continued addition of Na^+ the potential reaches zero and then plus 40-50 millivolts. This is the peak of the action potential.
(vi)The permeability of a depolarised membrane to Na^+ then rapidly drops, now there are as many Na^+ on the inside of the membrane as on the outside.

b. The light rays in visible wavelength focused on the retina through the cornea and the lens generate impulses in rods and cones. The light induces dissociation of the retinal from opsin which results in the changes of the structure of the opsin. Due to this the membrane permeability changes. Due to this the potential differences are generated in the photoreceptor cells. These are responsible to produce a signal that generates action potentials in the ganglion cells through the bipolar cells. These action impulses are transmitted by the optic nerves to the visual cortex area of the brain, where the neural impulses are analysed and the image formed on the retina is recognized based on earlier memory and experience.

c. The external ear receives sound waves and directs them to the eardrum. The eardrum vibrates in response to the sound waves and these vibrations are transmitted through the ear malleus, incus and stapes to the oval window. The vibrations are passed through the oval window onto the fluid of the cochlea, where they generate waves in the lymphs. The waves present in the lymphs induce a ripple in the basilar membrane. These movements of the basilar membrane bend the hair cells by pressing them against the tectorial membrane.Due to this the nerve impulses are generated in the associated afferent neurons. These impulses are transmitted by the afferent fibers through the auditory nerves to the auditory cortex of the brain, where the impulses are analysed and the sound is recognised.

Question 9. Differentiate between:

(a) Myelinated and unmyelinated axons

(b) Dendrites and axons

(c) Rods and cones

(d) Thalamus and Hypothalamus

(e) Cerebrum and Cerebellum

Answer:

a) Myelinated and unmyelinated axons

	Myelinated axons		non-myelinated axons
1	Myelin sheaths are present.	1	Myelin sheaths are absent.
2	Nodes of ranviers are present.	2	Nodes of ranviers are absent.
3	The conduction of nerve impulse is node to node.	3	The conduction of nerve impulse is smooth.
4	These are found in grey matter of the brain, autonomous nervous system, spinal cord	4	These are found in the spinal cord, white matter of the brain, autonomous nervous system
5	These are almost 50 times faster than that of non-myelinated axons.	5	These are comparatively lower.

b) Axon and dendrites :

	Axon		Dendrites
1	This carries the impulse away from the cell body of the neuron.	1	This carries the impulse towards the cell body of the neuron.
2	These are long processes.	2	These are short processes.
3	These may or may not be branched.	3	These are always present in the branches.
4	Here the Nissl's granules are absent in neoplasm.	4	Here the Nissl's granules are found in neoplasm.

c) Rods and cones

	Rods		Cones
1	These are sensitive to the dim light.	1	These are sensitive to the bright light.
2	They contain rhodopsin pigment.	2	They contain iodopsin pigment.
3	They are not involved in the colour vision	3	They are crucial in imparting colour vision.
4	They are of one kind only.	4	These are of three kinds such as – red, blue, green lights

d. Thalamus and Hypothalamus

	Thalamus		Hypothalamus

1	They consist of only grey matter.	1	They consist of white and grey matter.
2	They do not secrete hormones.	2	They secretes several hormones that control the activity of pituitary gland.
3	These are found above the midbrain.	3	These are found in the base of the thalamus.
4	They have the centre for sensations namely – cold, pain, heat.	4	They has the centre for sensations namely – regulating body temperature, homeostasis, blood pressure.

e. Cerebrum and Cerebellum

	Cerebrum		**Cerebellum**
1	The brain is majorly covered by the cerebrum.	1	It is the second largest part of the brain after cerebrum.
2	It is part of the forebrain.	2	It is part of the hindbrain.
3	It is of two cerebral hemispheres.	3	It is of three lobes such as– central vermis, two lateral cerebral hemispheres.
4	It is the centre for intelligence and for memory.	4	It is the centre for the posture and the body equilibrium.

Question 10. Answer the following:

(a) Which part of the ear determines the pitch of a sound?

(b) Which part of the human brain is the most developed?

(c) Which part of our central neural system acts as a master clock?

Answer:

(a) The receptor cells in the organ of Corti (Internal ear) is the part of the ear that determines the pitch of sound.
(b) Cerebrum (cerebral hemispheres) is the most developed part of the human brain.
(c) Pineal gland present in diencephalon of the forebrain acts as a master clock, which maintains biological rhythm.

Question 11. The region of the vertebrate eye, where the optic nerve passes out of the retina, is called the

(a) fovea (b) iris (c) blind spot (d) optic chiasm

Answer:

The correct answer is option (c). The region of the vertebrate eye, where the optic nerve passes out of the retina, is called the blind spot.

Question 12. Distinguish between:

(a) afferent neurons and efferent neurons

(b) impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre

(c) aqueous humor and vitreous humor

(d) blind spot and yellow spot

(e) cranial nerves and spinal nerves.

Answer:

(a) afferent neurons and efferent neurons

	Afferent neurons		**Efferent neurons**
1	The afferent neurons are the sensory neurons.	1	The different neurons are the motor neurons.
2	The conduction of the sensory impulses from the receptors towards the central nervous system.	2	The conduction of the motor impulses from the central nervous system to the responsive or effector organs.
3	They are located in the sense organs.	3	These are found in the brain and the spinal cord.

(b) impulse conduction in a myelinated nerve fibre and unmyelinated nerve fibre

	Impulse conduction in a myelinated nerve fibre		**Impulse conduction in an unmyelinated nerve fibre**
1	The impulse is transmitted from node to node.	1	Here the impulse travels across the length of the nerve fiber.
2	The speed of the impulse-conduction is almost 50 times faster than non- non-myelinated axon.	2	These are comparatively lower.
3	Here the less amount of energy is expended during the transmission of an impulse.	3	Here the excess energy is expended during the transmission of an impulse.

(c) aqueous humor and vitreous humor

	Aqueous humor		**Vitreous humor**
1	These are found in the aqueous chamber between the cornea and lens.	1	These are found in the vitreous chamber between the retina and lens.

2	They are produced by the ciliary processes.	2	They are produced by the retina of the eye.
3	They have a jelly-like consistency.	3	They have a watery consistency.
4	They provide support to the lens.	4	The renders support to the lens and retina.

(d) blind spot and yellow spot

	Blind spot		**Yellow spot**
1	This is a point on the retina where the optic nerve exits the eye while the retinal blood vessels enter the eye.	1	This is a point on the retina which is found exactly opposite to the center of the cornea.
2	They do not contain photoreceptor cells.	2	They contain two kinds of photoreceptor cells such as rods and cones.
3	These are not sensitive to light.	3	These are light-sensitive.
4	This is not a functional in vision	4	Here the yellow spot is the region that has the most distinct vision.

(e) cranial nerves and spinal nerves.

	Cranial nerves		**Spinal nerves**
1	In the human body there are 12 pairs of cranial nerves present.	1	There are 31 pairs of spinal nerves present.
2	These nerves emerge from the brain and extend to other parts of the body.	2	These nerves originate from the spinal cord, extending to other parts of the body.
3	The cranial nerves can be mixed, motor or sensory as well.	3	The spinal nerves are the mixed nerves.