Answers

2.6 Nervour Tissue

192. a + b – c + d + e +
Neurons possess characteristics of irritability and conductivity. In additional to the cell body, neurons possess process (dendrites and axons). Neurons have a neuroectodermal origin.

193. a + b + c + d + e +
Neurofibrils, which are seen in light microscopic preparations of nervous tissue after impreganation with silver salts, are found in all nerve cells including the area of the perikarya and the neuronal processes. Electron microscopy reveals these neurofibrils to be composed of bundles of neurofilaments and neurotubules.

194. a + b + c – d – e +
The axon hillock, which is the source of origin of the axon, lacks Nissl substance. As there is only the axon per neuron, there is only a single axon hillock per neuron.

195. a – b + c – d + e +
Axonic transport and flow occurs in both directions within axons. It is believed to serve a trophic function and transport essential metabolites throughout the length of the axon and remove waste products. Axonic flow is important in the production of neurotransmitters of synapses.

196. a + b + c + d + e +
Post-embryonic neurons do not divide, but remain in a permanent interphase. They may undergo changes in volume or in the number or complexity of their processes. After injury, or if severed, a certain degree of regeneration may be possible in processes of peripheral nerves.

197. a + b + c + d + e +
Nerve cell bodies have large rounded nuclei with pronounced nucleoli and a fairly lightly staining nucleoplasm. The perikarya are rich in mitochondria, rough endoplasmic reticulum and have well-developed Golgi bodies. Perikarya are sites of large numbers of synapses with processes of other neurons.

198. a + b + c – d – e –
The receptive segment of multipolar neurons includes the dendrites and perikaryon.

199. a – b – c – d – e +
Nissl bodies are sites of rough endoplasmic reticulum. They are found mainly in the perikarya, apart from the area of the axon hillock. They may also be found to a certain degree in the area of dendrites close to the perikarya.

200. a + b + c + d + e +
Nuclei of neurons are found in the area of the cell body and surrounded by perikarya. The nuclei are large and regular with prominent nucleoli. The nuclei stain poorly as their chromatin is dispersed. In females sex chromatin may be identified.

201. a + b + c – d – e +

202. a + b + c + d + e +

203. a – b + c + d + e –
Axons are processes of nerve cells that are usually longer and fewer in number than dendrites of a particular neuron. Axons typically transmit impulses away from the perikarya. These impulses may be transmitted to other neurons, muscles or gland cells. Axons transmit impulses without decrement of the impulses. Axons which may be either non-myelinated or myelinated, are surrounded by oligodendroglia or Schwann cells. In some cases axons may be up to one meter long.

204. a + b + c + d + e –

205. a + b – c – d – e +
Dendrites are processes of neurons that can receive impulses and transmit them, decrementally, towards the perikarya. They are typically more numerous than axons and shorter. They may have several synapses with other neuronal processes. Dendrites contain neurotubules and are of a fairly constant diameter.

206. a + b – c + d – e +
Multipolar neurons are the most common morphological type of neuron. They have a number of short dendrites, but only a single axon. The motor neurons (motoneurons) including those of the autonomic nervous system are multipolar. Like all neurons, multipolar neurons are not well stained in hematoxylin and eosin preparations and do not reveal their processes. The neurons and their processes can be identified after impregnation with silver salts.

207. a + b + c + d – e +
True bipolar neurons with a single axon and a single dendrite have a very restricted distribution in the body. They are found in the retina and in vestibular, cochlear and olfactory nerves.

208. a – b + c + d + e +
Unipolar or ‘pseudounipolar’ neurons have one short process that divides into two long processes. The cell body is located in spinal ganglia of spinal nerves or in some sensory ganglia of craninal nerves. The unipolar neurons can be considered as modified bipolar neurons. During evolution there w as a fusion of the two processes.during the embryological development of afferent neurons in the dorsal root ganglia, we find a similar fusion of processes.

209. a – b – c + d + e –

210. a + b – c + d + e +

211. a + b – c + d + e +

212. a – b + c + d – e –
The myelin sheath of axons may be formed by Schwan cells in the peripheral nervous system or by oligodendrocytes in the central nervous system. Myelin is composed of lipoprotein and is both well preserved and stained black with osmium tetroxide owing to its high phospholipids content. Electron microscopy reveals that the myelin sheath is formed many concentrically arranged membranes of Schwann cells or ligodendrocytes wrapped around the axons. The myelin is not preserved well in normal wax-embedded preparations as the lipid component is leached out or dissolved in clearing agents, such as xylene.

213. a – b – c + d – e –
Mesaxons are found in the sheath of myelinated axons. During embryonic formation of the myelin sheath, the axon penetrates a groove of the Schwann cell cytoplasm. The edges of the groove come together to form the mesaxon and the two plasma membranes fuse. The mesaxon wraps itself around the axon several times, after which an internal and external mesaxon can be seen in transverse sections of myelinated nerves when viewed by transmission electron microscopy.

214. a + b – c – d – e +
Non-myelinated nerve fibers are surrounded by a fold oligodendrocyte or Schwann cell are very common in the gray matter of the central nervous system.

215. a + b + c + d + e +

216. a – b + c + d – e –

217. a – b + c – d + e –
In teased preparations from whole peripheral myelinated nerves stained with osmium tetroxide it is possible without any great difficulty to identify nodes of Ranvier, internodes, axons, muclei of Schwann cells and incisures of Schmidt-Lantermann. These incisures of Schmit-Lantermann are only seen in myelinated

nerves and are cone-shaped disruptions or shearing defects of the myelin sheath in the area of the internodes.

218. a + b – c + d + e +
'Neurokerating' is a preparational artifact seen in myelinated nerves after regular fixation (in formaldehyde), wax-embedding and staining with hematoxylin and eosin. It is in the form of a loose network at the site of myelin sheaths and consists or residual protein after the lipid elements have been extracted during processing.

219. a – b + c + d + e +
Nodes of Ranvier are found in myelinated axons of both the CNS and the PNS. The nodes are bounded by paranodal loops of Schwann cells. The nodes of Ranvier allow saltatory conduction and a more efficient non-decremental impulse conduction. This is possible because active ion-exchange is only possible in the area of the nodes, where no insulating myelin layer is present.

220. a + b + c – d + e +
In normal histological preparations non-myelinated peripheral nerves are superficially fairly similar in appearance to smooth muscle bundles. When seen in longitudinal section, however, the non-myelinated nerve fibers are usually undulating and of a variety of diameters and they may also contain isolated myelinated fibers. Moreover, the nuclei of Schwann cells are peripheral of the individual fibers in contrast to the nuclei of smooth muscle cells which are found within each cell.

221. a – b + c + d – e +
The endoneural connective tissue sheath (of Key and Retzius) surrounding nerve fibers is derived from mesenchyme and is composed of a delicate network of reticular fibers, which can be visualized for light microscopy by impregnation techniques using silver salts. The myelin sheaths are produced by Schwann cells or oligodendroglia, which originate from neural ectoderm.

222. a – b + c + d + e –

223. a – b + c + d – e –

224. a + b + c + d – e +

225. a + b – c + d + e +

226. a + b – c – d – e +
Neuroglia are supporting cells for neurons, which cannot function in the absence of neuroglia. The neuroglia provide both a nutritive and defensive role in the support of neurons. The neuroglia are not well seen after staining with hematoxylin and eosin, which only shows their nuclei well. In order to demonstrate the processes of neuroglia it is necessary to sue silver or gold

impregnation techniques. Neuroglial cells differ from neurons in that they can divide in post-natal life and lack the neuronal properties of irritability and conductivity. The number of neuroglia is estimated to be about ten times greater than the number of neurons,though because they are mostly smaller than neurons they occupy a smaller overall volume. Neuroglia develop from the ectoderm of the embryonic neural tube with the exception of the microglia, which develop from mesenchyme and function as macrophages. Ependymall cells and neurons originate from the ectoderm of the embryonic neural tube. The microglia have densely staining elongated nuclei and are found in both white and gray matter.

227. a – b + c + d + e +
Astrocytes are the largest of the neuroglia and posses several fairly long processes. These may be in the form of pedicles which terminate on small blood vessels and which are believed to participate in the blood-brain barrier (BBB). The nuclei of astrocytes are lightly stained. Astrocytes form part of the neuropil. The protoplasmic astrocytes are predominantly found in the gray matter of the brain and spinal cord. The fibrous astrocytes are chiefly found in the white matter.

228. a + b + c + d – e –
Oligodendrocytes are smaller than astrocytes and are found in both gray and white matter. The myelin sheath of central nerous tissue is produced by oligodendrocytes.

229. a + b – c – d + e +

230. a + b + c + d + e +
Spinal (dorsal root) ganglia are paired structures located in intervertebral foramina and are part of the reflex arcs that function in the transmission of afferent impulses to the spinal cord. Histological prepartions of spinal ganglia show groups of large perikarya, each surrounded by satellite cells (oligodendroglia). A thin layer of fibrous connective tissue envevlopes individual perikarya and their satellite cells. The processes emerging from the neuronal cell bodies are T-shaped, consisting of a single axon that divides into two (unipolar or ‘pseudounipolar’). Myelinated fibers are also found in the spinal ganglia.

231. a + b + c + d + e +

232. a + b – c + d + e +

233. a + b – c – d – e +
Components of every reflex are include a receptor, sensory (afferent) neutron, synapses, motor (efferent) neuron and effector. This is best seen at its simplest in spinal reflec arc, where the receptors are lined to the effectors by a series of neurons. Impulses in reflex arcs travel in one direction only – from the receptor to the effector. The reflex arc may incorporate a large number of interneurons located between the afferent and efferect neurons. The afferent (sensory) neurons

of spinal reflex arc are found in the dorsal root with their cell bodies located in the spinal (dorsal root) ganglia. These afferent neurons enter the dorsal horn of the gray matter of the spinal cord.

234. a + b – c – d – e –
The large motor neurons which send myelinated axons to the extrafusal muscle fibers of neuro-muscular spindles (NMS) are called alpha motor neurons. The gamma motor neurons terminate on the intrafusal fibers of the NMS. The periarya of both the alpha and gamma motor neurons are found in the ventral horn of the spinal cords.

235. a – b + c + d – e +

236. a + b + c + d + e +

237. a – b – c + d + e –
Synapses are found connecting axon to axon, axon to dendrite, dendrite to dendrite, axon to perikaryon and axon to muscle (motor endplate). Chemical synapses are characterized by a persynaptic bulb with concentrations of mitochondria and synaptic vesicles, which contain the transmitters. Electron microscope studies have indicate differences in the shape of synaptic vesicles according to the type of synapse. Inhibitory synapses usually have more flattered vesicles, whereas in excitatory synapses the vesicles are usually more rounded.

238. a – b + c – d + e –
Electrical synapses are found in restricted sites and are much less common than chemical synapses. They are found at the junction between the bipolar neurons and ganglion cells in the retina. The nexus (gap junction) between adjacent smooth muscle cells and in intercalated disks of cardiac muscle can be considered as a form of electrical synapse. In electrical synapses the pre-synaptic and post-synaptic membranes are closely applied and lack the characteristic synaptic cleft of chemical synapses and also lack synaptic vesicles with transmitters. Electrical synapses are non-polarized and the nerve impulses can be transmitted in both directions. There is no synaptic delay in electrical transmission and so the speed of impulse transfer from neuron to neuron is much greater than in chemical synapses.

239. a + b – c + d + e +

240. a – b + c – d + e +
Myoneural junctions (motor endplates) have an axon, mitochondria and synaptic vesicles in the pre-synaptic zone. The pre-synaptic and post-synaptic membranes are separated by a synaptic cleft. The post-synaptic membrane has many invaginations and is rich in receptor sites for transmitters. Activity of acetylcholinesterase, which breaks down the transmitter, acetylcholine, can be localized on the post-synaptic membrane.

241. a + b + c – d – e +

242. a + b + c + d + e +
Neuromuscular spindles (NMS) are encapsulated sensory receptors of skeletal muscle and are involved in the muscle stretch, reflexes. They are quite large receptors reaching some 3-5 mm in length and are situated in parallel with the muscle fiber. They are most numerous in muscle needing fine control. Neuromuscular spindles have both extrafusal fibers (outside the spindle) and intra-fusal fibers. The innervation of neuromuscular spindles in quite complex. The nuclear bag fibers are innervated by large myelinated sensory fibers (primary afferents), which terminate in annulospiral endings.

243. a + b + c – d + e –
The white matter of the spinal cord contains mainly myelinated fibers in large numbers transmitting impulses up and down the cord. The white appearance is mainly due to the myelin. There are also some non-myelinated nerve fibers. No cell bodies of neurons are found in the white matter, though neuroglial cells are pesent. They cell bodies of neurons are found in the gray matter of the brain and spinal cord and in spinal ganglia.

244. a – b + c + d + e –

245. a – b + c – d – e –
Neuropil is found in the gray matter of the nervous system and is composed of complex network of dendritic, axonal and glial processes. The neuropil has a very high concentration of synapses. Most of the axonal processes are non-myelinated.

246. a + b – c – d + e +
Gamma motor neurons have their cell bodies in the anterior (ventral) horn of the spinal cord. Their axons are lightly myelinated and smaller than those of the alpha motor neurons. The gamma motor neurons (or fusimotor neurons) innervate the intrafusal fibers of NMS receptors, while the large alpha motor neurons innervate the extrafusal fibers.

247. a – b – c – d – e +
Non-encapsulated receptors are older in phylogenetric terms than the encapsulated receptors. Non-encapsulated receptors or free nerve endings are very common in the skin. They are also found elsewhere including the cornea of the eye, in various mucous membranes and in the pulp of teeth. They are believed to respond and give sensations of pain and touch and other subjective responses such as cold and warmth.

248. a + b + c – d – e +
The Corpuscle of Vater-Pacine (Pacinina Corpuscles) are encapsulated receptors that may be from 1-4 mm long and are easily visible to the naked eye. They look somewhat like miniature onions and function as pressure receptors. The corpuscles are supplied with one or more thick myelinated nocis, that lose their myelin on entering the corpuscle. Vater-Pacini corpuscles are common in the dermis of the skin, especially that of the thick skin of the hands and feet, and are found elsewhere including the pancreas.

249. a + b – c + d – e +
Meissner bodies (corpuscles) are tactile encapsulated receptors found in the dermal papillae of the skin, just beneath the epidermis. They are mainly found in the thick skin of the hands and feet.

250. a + b + c + d + e +
Golgi tendon organs (neurotendinal spindles) are encapsulated receptors found in tendons, aponeuroses and joint ligaments. They function as tension receptors as part of the proprioreceptor system that allows a blindfolded person to know the position of his limbs or to regulate the muscular effort needed to perform a particular movement.

251. a + b + c – d – e –
Ependymal cells line the ventricles of the brain and the central canal of the spinal cord. They are less well developed in adults than in fetuses. Ependymal cells are derived from the inner cells of the embryonic neural tube, but are not neurons. They function in adults as a lining tissue and have a special role in the choroids plexuses.

252. a + b + c + d + e –

253. a + b + c + d – e –
Choroid plexuses are found in all the ventricles of the brain and number four in total. They are composed of an epipthelium derived from ependymal cells of the embryonic neural tube. These epithelial cells have microvilli on their free surface, tight junctions and relatively large numbers of mitochondria. In fetuses the epipthelial cells may be ciliated and contain considerable amounts of glycogen, though these features are lost after birth. The choroids plexuses are the source of cerebrospinal fluid (CSF).

254. a + b + c – d – e +
Cerebrospinal fluid (CSF), which is produced by the choroids plexus, is important in protecting the brain and spinal cord from mechanical damage and it also has a

nutritive role. The CSF is absorbed into the venous blood via the arachnoid granulations found in the dura mater.

255. a – b – c + d + e +
The dura mater is the most external of the meninges and is the toughest of these coasts being composed of dense connective tissue. The dura mater is continuous with the preiosteum of the skull bones and is lined internally with a simple squamous epithelium.

256. a – b + c + d + e +
The pia mater is the most internal of the menings and is highly vascularized. It is in close contact with the brain surface an follows the contours of the brain. The pia mater is covered
by an external layer of squamous cells of mesenchymal origin.

257. a + b + c – d + e +
Neurosecretory neurons are specialized neurons that in addition to the normal functions of neurons have the ability to synthesize and secrete hormones. They often can be identified in histological preparations using special staining techniques such as the chrome alum-hematoxylin-phloxine staining method. Neurosecretory neurons are found in the hypothalamus, where they are responsible for the synthesis of the hormones oxytocin and vasopressin and the transport of these hormones to the neurohypophysis.

258. a + b + c + d + e –
If a peripheral axon is severed or badly damaged a number of histological changes are seen in the perikaryon of the neuron. The perikaryon swell, Golgi bodies are disrupted and the Nissl bodies disappear, usually beginning in a more central part. The nucleus of the neuron is usually displaced from its increased RNA and nucleoprotein synthesis. This process of degeneration in perikarya following axonal injury is sometimes referred to as ‘retrograde degeneration’.

259. a – b + c + d – e +
Ganglia are concentrations of cell bodies of neurons and are found in the peripheral nervous system only. They are present either as (i) spinal (cerebrospinal) ganglia or (ii) visceral (autonomic) ganglia. These differ in location, histology and function. The spinal ganglia have unipolar (‘pseudounipolar’) neurons, whereas the neurons of autonomic ganglia are multipolar. The nuclei of the neurons in the visceral ganglia are usually more eccentrically located in the perikarya, while those of the spinal ganlia are more central. The inner ear is the site of the spiral ganglion situated in the modiolus. The so-called ‘basal ganglia’ of the brainstem are not true ganglia.

260. a – b + c + d + e +
The cerebral cortex is composed of six basic layers of laminae. The layers can be shown by various techniques including stains for Nissl substance, Golgi

impregnation or stains for myelin. The neocortex, which comprises some 90% of the cerebral cortex of adults, has six horizontal layers of neurons in most area. Where these six layers are clearly defined, this is called an 'homotypical' cortex. Where the basic six layers are not clearly defined it is termed 'heterotypical'. When the heterotypical cortex has only relatively few granule neurons, it is called 'agranular', as opposed to the 'granular' cortex, which has large numbers of granule (stellate) neurons. The archicortex and paleocortex, which are older phylogenetically than the neocortex, are usually poorly laminated and if layers are seen these are fewer than six, typically three.

261. a + b + c + d – e –

262. a – b + c – d + e +

263. a + b + c + d + e –
Golgi type I neurons contribute to the formation of peripheral nerves are typically have long axons, which also form the long fibers tracts of the spinal cord and brain. Golgi type II neurons are found entirely within the gray matter and are especially numerous in the cerebral cortex and in the cerebellar cortex, where they are found in all the cortical laminae. Golgi type II neurons (stelate or granule cells) have relatively short non-myelinated axons and extensive branched dendrites.

264. a – b + c – d + e +
The largest cells visble in preparations of the cerebal cortex are the Betz cells, which are multipolar pyramidal neurons. Betz cells are most conspicuous in the motor area (precentral
gyrus).

265. a + b + c + d + e +
Pyramidal cells are the most prominent neuronal type in the cerebral cortex. A long dendrite extends from the apex of each pyramidal cell body and terminates in the molecular layer. Extremely large numbers of synapses are found on this dendrite. A single axon leaves the base of the pyramidal cell body and extends into the subcortical white matter. Pyramidal cells are easily demonstrated by Golgi impregnation
methods and the largest and most conspicuous of the pyramidal cells are the Betz cells.

266. a + b – c + d – e +
The horizontal cells of Cajal are relatively small neurons found in the molecular layer of the cerebal cortex. These neurons are oriented almost entirely in the horizontal plane so that both dendrites and axons run in parallel to the cortical surface. These neurons are rarely found in adults, but are much more commonly found in infants and young children.

267. a – b – c + d + e +
The cells of Martinotti are small multipolar neurons found in most of the layers of the cerebal cortex. These neurons have ascending myelinated axons running in the direction of the cortical surface and typically terminating the molecular layer. These neurons are solely concerned with intracortical activities.

268. a + b + c + d + e +
The bands of Baillarger are visble to the naked eye when seen in fresh slices of the cerebral cortex. These bands are well seen in sections stained for myelin. The bands are composed of large numbers of horizontally arranged fibers. In sensory areas of the cerebral cortex the bands of Baillarger are very well developed owing to the high concentration of the terminal parts of thalamocortical fibers.

269. a + b + c – d + e +
The line or band of Gennari is found in the visual (striate) cortex,which is an heterotypical granular cortex. The line of Gennari, which is visible to the naked eye in fresh brain slices or in sections stained for myelin, is formed from an enlarged outer band of Baillarger.

270. a – b + c + d + e –
The cerebellar is composed of three distinct layers: an outer molecular layer, followed by a layer containing the large and conspicuous Purkinje neurons, and an inner granular layer. Pyramidal cells are only found in the cerebral cortex.

271. a + b + c + d + e –
Purkinje cells are the largest neurons found in the cerebellar cortex and can be demonstrated by silver impregnation methods. These flask-shaped neurons, though easily seen, are far less numerous than the granule cells. Purkinje cells have bifurcating dendrites, somewhat like antlers of a stag. The Purkinje cells are situated in a row between the molecular and granular layers.

272. a + b + c + d + e +
The granular layer of the cerebellar cortex has very large quantities of small neurons called granule cells. The nuclei of these neurons, unlike most neurons, are darkly staining and the cell bodies have relatively little cytoplasm. Larger stellate (Golgi type II) cell are also present in the granular layer. There are also ‘clear’ areas or glomeruli in the granular layer. These represent areas devoid of neuronal cell bodies, but where very large numbers of synapses are found.