# Structural Elements of the Nervous System: Dorsal Root, Autonomic & Enteric Ganglion and the Brain

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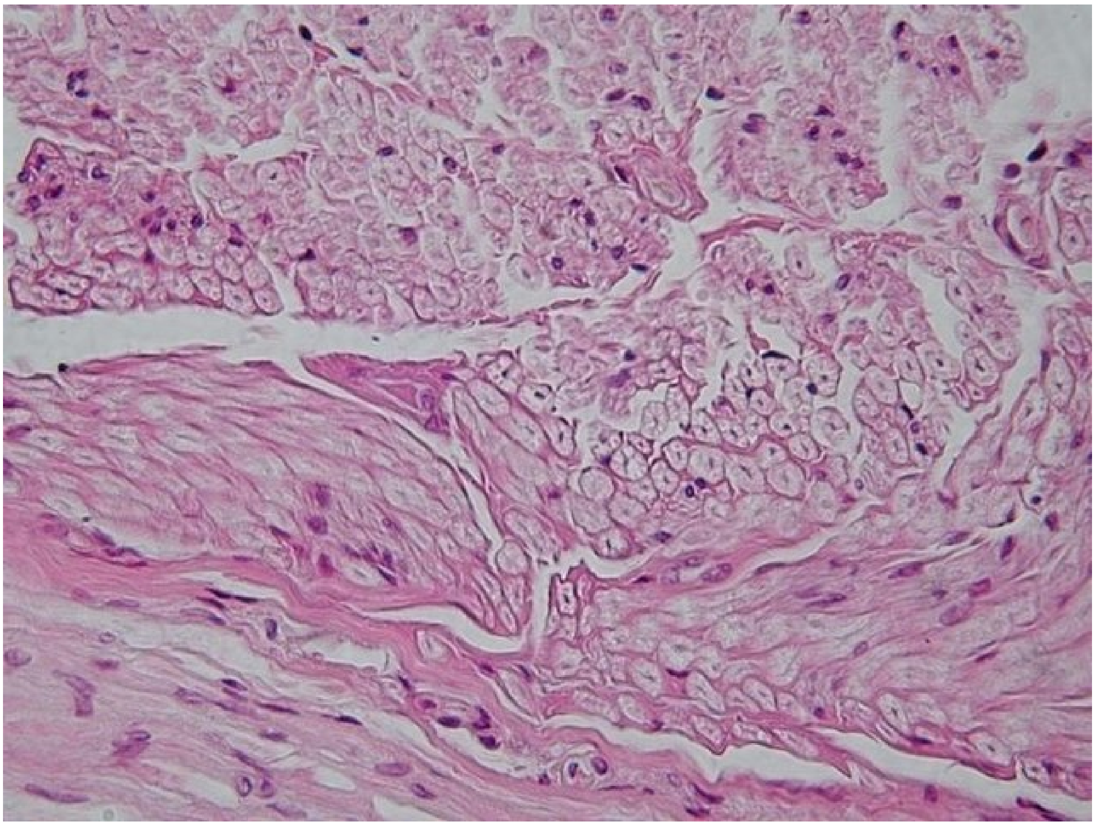
**Nerve tissue is a highly specialized tissue of the human body. The nervous system is one of the most complex, intricate and sophisticated systems in the human body. This article envisages putting forth basic information about various structural elements of the nervous system, such as the dorsal root ganglion, autonomic ganglion, enteric ganglion, and the brain.**



## Introduction

The human nervous system is one of the most specialized, complex and highly organized systems in the body designed to perfection. Its impeccable nature has its origins in its structural organization.

The human nervous system can be **grossly segregated into the central and the peripheral nervous system**. While the brain and the spinal cord constitute the central nervous system, the peripheral nerves and sympathetic and parasympathetic nerves along with their receptors and ganglions are part of the peripheral nervous system. We will now learn about the basic entities of the nerve tissue, such as the dorsal root ganglion, autonomic ganglion, enteric ganglion, and the brain.

## Dorsal Root Ganglion

**The cell body (soma) of the sensory neuron is located in the dorsal root ganglion.** The special clusters of nerve cells located at the base of spinal nerves are termed as dorsal root ganglion, spinal ganglion or posterior root ganglion. They originate from neural crest cells and are analogs to the grey matter of the spinal cord. This ganglion collects and transmits messages of pain and touch.

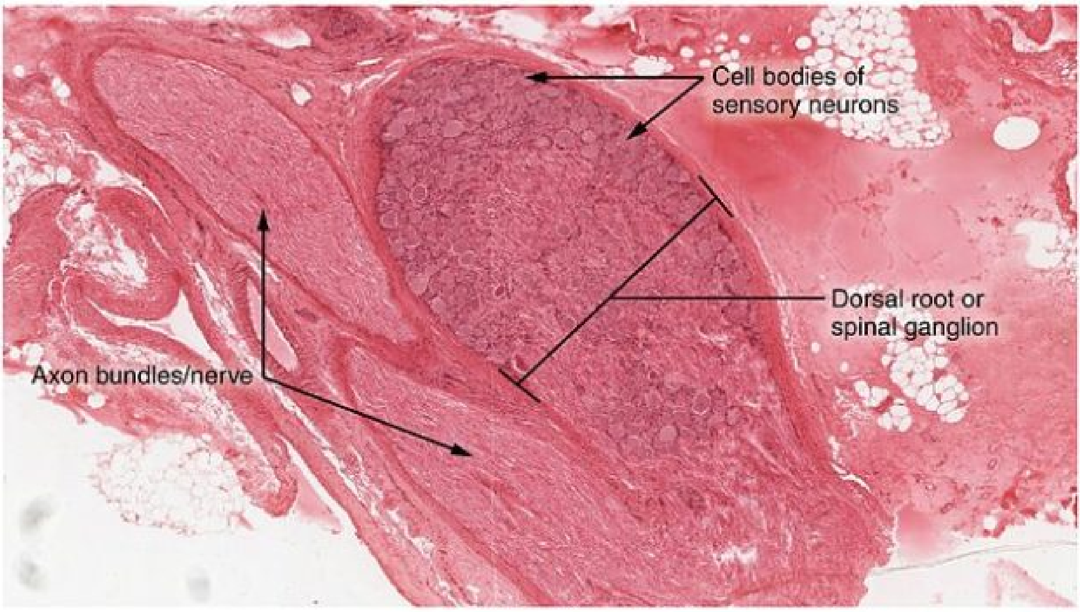



Image: “Dorsal Root Ganglion” by OpenStax. License: CC BY 4.0

Presynaptic regulation of dorsal root ganglion is facilitated by GABA A receptors control nociception and pain transmission.

## Autonomic Ganglion

Autonomic ganglion are clusters of neuron cells acting as a junction between the autonomic nervous system and the central nervous system crossing target organs at the periphery. It is **responsible for the subconscious regulation of the functioning (involuntary movements) of the human body**.

It is indispensable for the **maintenance of homeostasis** and the harmonious “milieu interior.” The cell bodies of the neurons of the autonomic system are situated in the autonomic ganglia. There are two kinds of autonomic ganglia; namely, the sympathetic and the parasympathetic ganglia.

### The sympathetic ganglia

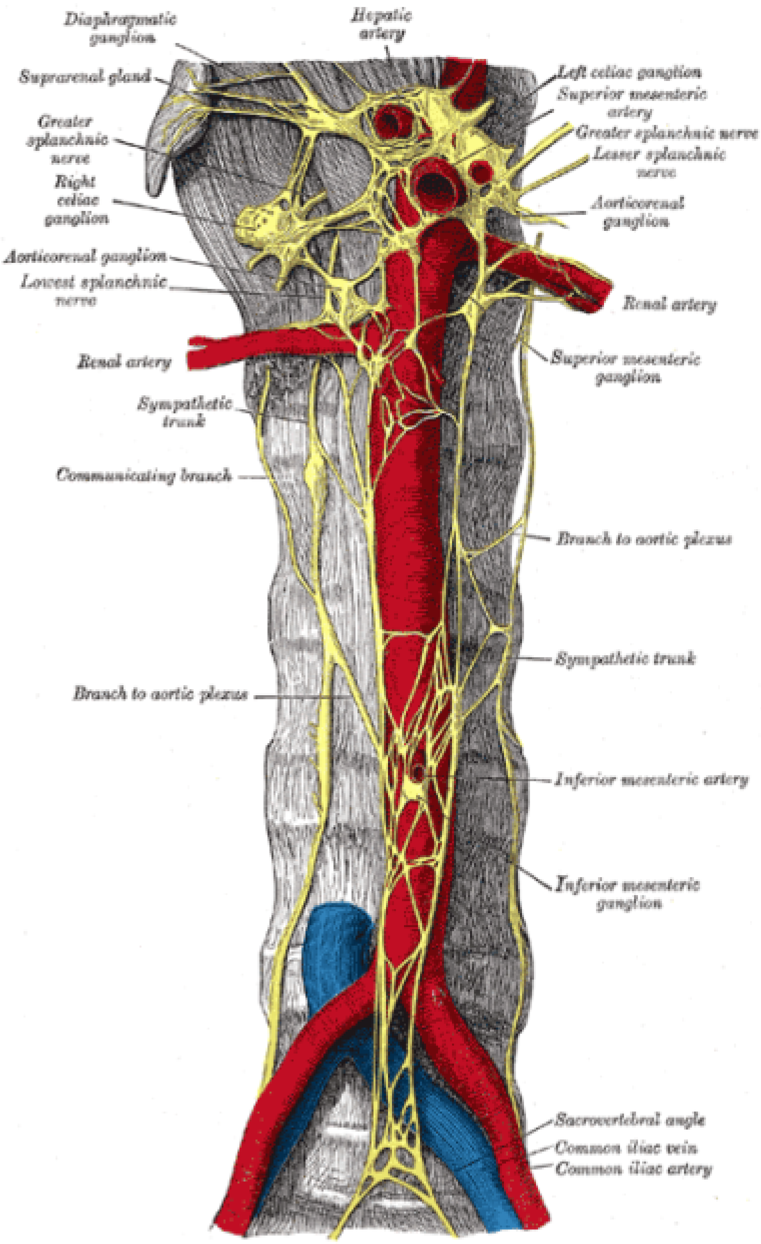



Image: "Abdominal portion of the sympathetic trunk, with the celiac and hypogastric plexuses." by Henry Vandyke Carter – Henry Gray. License: Public Domain

The sympathetic ganglia are **arranged in a prevertebral and paravertebral chain of ganglia**. The prevertebral ganglia, also known as the collateral ganglia, are designated for the abdominal and the pelvic organs. They are **fed by the splanchnic nerves** and are named mostly after the associated vasculature. Celiac ganglia, superior mesenteric ganglia, and inferior mesenteric ganglia are some of the famous illustrations.

The sympathetic autonomic ganglia form a chain of paravertebral ganglia in the sympathetic trunk. There are about **22 pairs of these ganglia**. They contain about 25,000 cell bodies and are responsible for the flight-or-fight response. The sympathetic ganglia are segregated as per the vertebral level against which they lie and can be listed as follows:

- Cervical ganglia in the cervical region: 3 in number (superior, middle and inferior cervical ganglion).
- Thoracic ganglia in the thoracic region: 11 in number.
- Lumbar ganglia in the lumbar region: 4 in number.
- Sacral sympathetic ganglia in the sacral region: 4—5 in number.

- 1 unpaired coccygeal ganglion.
- The first thoracic and inferior cervical ganglia are fused to form the stellate ganglion.

A few salient features of the sympathetic connections between the ganglia and the spinal cord can be summarized as follows:

- The sympathetic nerve fibers arise from the thoracolumbar lateral gray matter of the spinal cord (T1—L2).
- They enter the ventral motor root.
- They enter the respective level spinal nerve through the white ramus communicans and pass on to the sympathetic chain.
- A single preganglionic fiber can synapse on to as many as 20 postganglionic fibers.
- The postganglionic fiber enters a relatively sparsely myelinated structure known as the gray ramus communicans. It enters the spinal nerve and is then directed to the peripheral plexus to reach the target organ.

**Note: Sympathetic ganglion conveys the information related to stress and approaching danger and helps to give fight and flight reactions.**

**The parasympathetic ganglia**

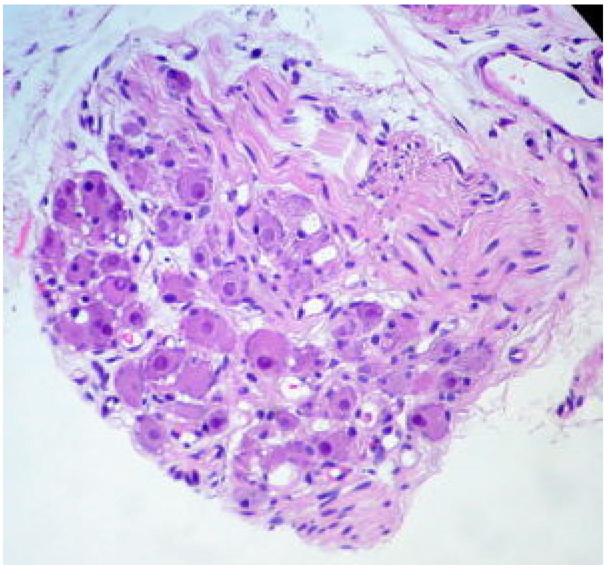


Image: "Parasympathetic Ganglion" by Ed Uthman. License: CC BY 2.0

The **parasympathetic autonomic ganglia are often located within the organs; i.e., they are visceral ganglia**. They also go by the name of "terminal ganglia" or "intramural ganglia." There are exceptions to this rule. The parasympathetic ganglia related to the cranial nerves supplying the head and neck region are named after its location and its supply. The above ganglions can be mentioned as follows:

- Otic ganglion related to IX cranial nerve supplying the parotid gland.
- Submandibular ganglion related to the VII cranial nerve supplying the submandibular glands.
- Pterygopalatine ganglion related to the VII cranial nerve supplying the nasal cavity glands and the lacrimal gland.
- Ciliary ganglion related to the III cranial nerve innervating the ciliary muscle and the sphincter pupillae muscles.

**Note: Ganglion is directly responsible for the control of the movement of the muscles involved.**

## Enteric Ganglion

These are often **located within the wall of the gut and are related to either the myenteric plexus or submucous plexus**. They also go by the eponyms of Auerbach's plexus and Meissner's plexus, respectively.

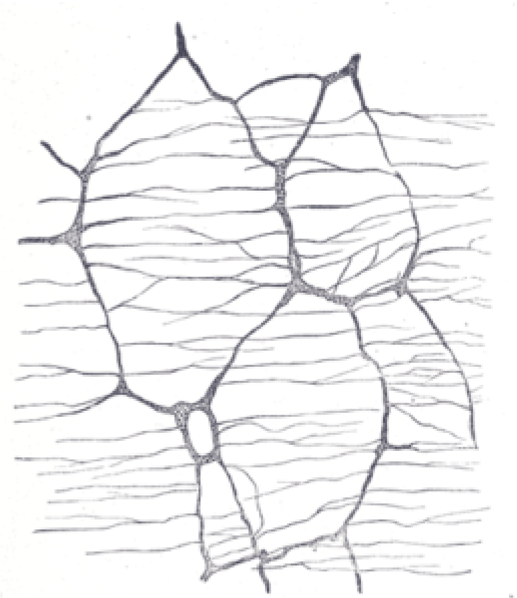


Image: "The myenteric plexus from the rabbit. X 50." by Henry Vandyke Carter – Henry Gray. License: Public Domain

The myenteric, or the Auerbach's plexus, innervates the circular and longitudinal muscle layers of the gut and is placed between them. The ganglia receive both parasympathetic and sympathetic input and mainly **provide motor innervations to the muscularis propria layers regulating the motility**.

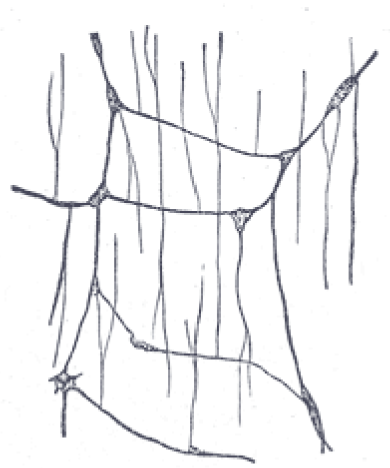


Image: "The plexus of the submucosa from the rabbit. X 50." by Henry Vandyke Carter – Henry Gray. License: Public Domain

The key structural elements involved can be summarized as follows:

- Origin in the cells of the vagal trigone in the medulla oblongata known as the “nucleus ala cinerea.” These cells are the parasympathetic neuronal entities related to the vagus nerve.
- The parasympathetic fibers traverse the vagus nerve in both the anterior and posterior components.
- They reach the Auerbach’s plexus.
- Approximately, one-third of the myenteric plexus consists of sensory neurons.
- The myenteric plexus also contains “Dogiel cells” which are actually found in the prevertebral sympathetic ganglia.

There are clinical conditions related to aberrant distribution of the enteric ganglia. The same can be briefly mentioned as follows:

| Pathology | Explanation |
|---|---|
| **Hirschsprung’s disease** | Absence of enteric ganglion cells subservient of the parasympathetic system in the myenteric plexus in the colon leads to this state of functional distal bowel obstruction. |
| **Achalasia** | A distinct decrement in the ganglion cell density in the myenteric plexus of the esophagus is associated with this motor disorder. |

# The Brain

The cerebral cortex consists of gray matter, white matter and nuclei. The cerebral cortex gray matter has neuropil and pyramidal cells.

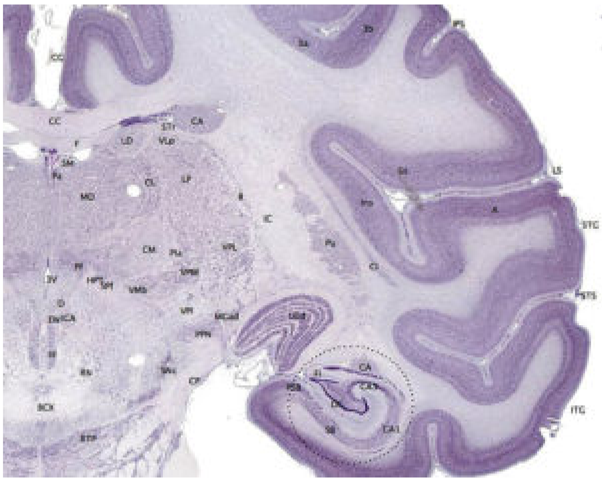


Image: “Tissue slice from the brain of an adult macaque monkey (Macaca mulatta). The cerebral cortex is the outer layer depicted in dark violet.” by brainmaps.org. License: CC BY 3.0

The cortex can be developmentally segregated into neocortex and allocortex; the latter being inclusive of archaecortex and paleocortex. These entities differ in the basic organization at the molecular level as well. The neocortex is the most developed and has six layers. The paleocortex has three cortical layers, while the archaecortex has about four to five layers.

The basic nature of these layers can be tabulated as follows:

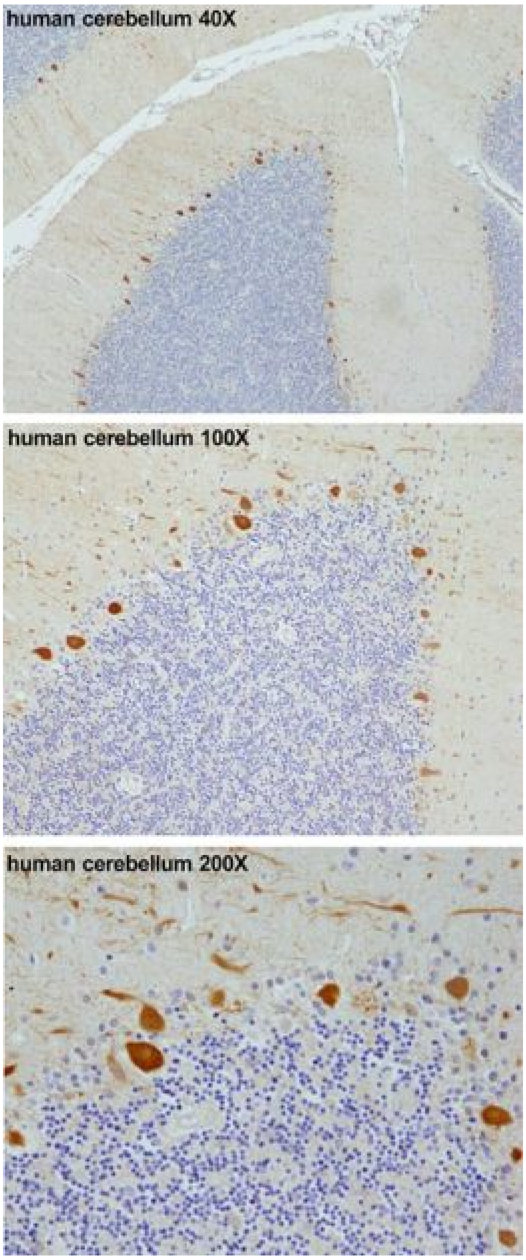
| Layer | Description |
|---|---|

| | |
|---|---|
| **Layer I: Molecular layer** | Pyramidal cell dendrites are mainly found in this layer. Associative learning is thought to correlate with the feedback interactions in this layer. |
| **Layer II: External granular layer** | Small pyramidal cells are present in this layer. |
| **Layer III: External pyramidal layer** | The majority of the small and medium-sized pyramidal cells are situated here. This layer predominantly outsources the majority of the cortico-cortical afferents. |
| **Layer IV: Internal granular layer** | The main destination for thalamocortical afferents, this layer contains stellate and pyramidal neurons. |
| **Layer V: Internal pyramidal layer** | The large pyramidal cells, also known as Betz cells, in the motor cortex are located here. They give rise to the pyramidal tract responsible for voluntary motor control. |
| **Layer VI: Polymorphic or multiforme layer** | Inclusive of a few large pyramidals and multiple small multiform neurons, this layer establishes a reciprocal efferent connection to the thalamus. |

The cerebellar cortex has a gray matter, white matter, and nuclei. The cerebellar cortex has been traditionally segregated into three layers. The same can be described as follows:

| **Layer** | **Description** |
|---|---|
| **Granular layer** | Granule cells, Lugaro cells, and Golgi cells are situated in this layer. |
| **Purkinje layer** | This layer comprises of the soma of Purkinje cells and Bergmann glial cells. |
| **Molecular layer** | Inclusive of the stellate and the basket cells, this layer homes the extensive network of neuronal fibers responsible for the impeccable functioning of the cerebellum. The Purkinje dendritic trees and parallel fibers are seen here. |

The salient features of the microscopic organization of the cerebellum can be mentioned as follows:




- Image: "The Purkinje cell protein 4 (PCP4) is markedly immunoreactive in the Purkinje cells of the human cerebellum. From top to bottom 40X, 100X and 200X microscopic magnifications. The immunohistochemistry was performed using a polyclonal rabbit anti-human PCP4 antibody purchased from SIGMA-ALDRICH and used according to the methods published by Felizola SJA et al 2014 Journal of Molecular Endocrinology 52(2):159-67. doi: 10.1530/JME-13-0248." by Herizora. License: CC BY-SA 3.0

The Purkinje cells and granule cells are the most important cells in the cerebellar circuit.

- Mossy fibers, climbing fibers, and parallel fibers are the most significant neuronal extensions responsible for accurately modulating the sensory-motor functions of the body.
- The axons of the granule cells constitute the parallel fibers.
- The mossy fibers have direct projections to the deep cerebellar nuclei. They also synapse onto the granule cells and indirectly modulate the Purkinje cells through the parallel fibers. The major source of mossy fibers is the

pontocerebellar pathway.
- The deep cerebellar nuclei are dentate, emboliform, globose and fastigial. The globose and emboliform nuclei together constitute the interposed nucleus.
- There are multiple repetitive representations of the body in the cerebellum. This is known as “fractured somatotopy.”

There are central and peripheral neuroglial cells in the nervous system. While the central neuroglial cells are located in the central nervous system, the peripheral neuroglial cells inhabit the peripheral nervous system. The few relevant significant examples of these types of neuroglial cells are as mentioned below:

| Type | Examples |
|---|---|
| **Peripheral neuroglia (PNS)** | Schwann cell<br>Satellite cell<br>Teloglia (motor endplate)<br>Enteric neuroglia (gut)<br>Muller’s cell (retina) |
| **Central neuroglia (CNS)** | Microglia: phagocytic cell<br>Ependymal cell: line fluid-filled cavities |

# Brain stem

The brain stem consists of midbrain, medulla oblongata and pons. The brain stem comprises cells that are responsible for motor and sensory functions of the body and form the nuclei of most cranial nerves. They are responsible for the control of activities of viscera, endocrine organs, behavior and muscular co-ordination of the muscles of the neck and the brain.

# Summary

Nerve tissue is highly specialized and one of the most complex, intricate and sophisticated systems in the human body.

The cell body (soma) of the sensory neuron is located in the dorsal root ganglion. These are typically situated at the side of the intervertebral foramina and are developmentally analogous to the brain gray matter.

Autonomic ganglion subserves the autonomic system responsible for the maintenance of homeostasis in the body. There are two kinds of ganglia, namely, the sympathetic and the parasympathetic autonomic ganglia.

Sympathetic ganglia are placed in prevertebral and paravertebral chains along the spinal cord and also segregated based on the parts of the spinal cord as cervical, thoracic, lumbar, sacral, and coccygeal. The prevertebral ganglia innervate the abdominal and pelvic organs.

The sympathetic nerve fibers enter the respective autonomic ganglia through the white ramus communicans and leave the ganglia to enter the spinal nerve through the gray ramus communicans.

Parasympathetic nerve ganglia are intramural or visceral, i.e., often located near the target organ. The ganglia in the head and neck region related to the cranial nerves are an exception to this rule.

Enteric ganglia are located in the myenteric plexus between the layers of the wall of the gut. The myenteric plexus, also known as Auerbach’s plexus, is located between the two muscle layers, while the submucosal plexus, also known as Meissner’s plexus, is located below the mucosa. The enteric ganglia are innervated by the parasympathetic neurons related to the vagal trigone in the medulla oblongata.

The cerebral cortex is often divided into neocortex, paleocortex, and archaecortex. The neocortex is the most advanced and has six layers. Layer V contains the giant pyramidal cells of Betz. While layer IV receives thalamic afferents, layer VI establishes reciprocal connection to the thalamus by sending efferents.

The cerebellar cortex has three layers; namely, the granular, Purkinje and the molecular layer. The climbing fibers and the mossy fibers provide cerebellar input and modulate the output of the Purkinje cells and the deep cerebellar nuclei.

There are two types of neuroglial cells in the nervous system. While the Schwann cell and enteric neuroglial cells are illustrations of peripheral neuroglial cells, microglia and ependymal cells are subcomponents of the central neuroglial cells.

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