Lecture 6
The Nervous system

الدكتور طارق جواد الربيعي

اختصاص جراحه عامه

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The nervous system

- The nervous system enables the body to react to continuous changes in its external and internal environments
- It controls and integrates various activities of the body

organization of the nervous system

- The human nervous system can be divided as follows based on the structure and function :

A. Structural classification .

B. Functional classification .

organization of the nervous system

A. Structural classification

Can be divided into two parts

1. The central nervous system (CNS) which consists of :

a. The Brain .

b. The Spinal cord .

(situated in the skull and vertebral column)

2. The peripheral nervous system (PNS) which consists of .

a. 12 pairs of cranial nerves.

b. 31 pairs of spinal nerves.

c. Their associated spinal and cranial ganglia

Ganglion : is cluster of nerve cells of a similar function outside the CNS

Organization of the Nervous System

B. Functional classification

Can be divided into two parts :

1. The somatic nervous system(SNS) or (the voluntary nervous system)

Mainly involved with receiving and responding to information from the external environments .

2. The visceral nervous system or (involuntary nervous system)

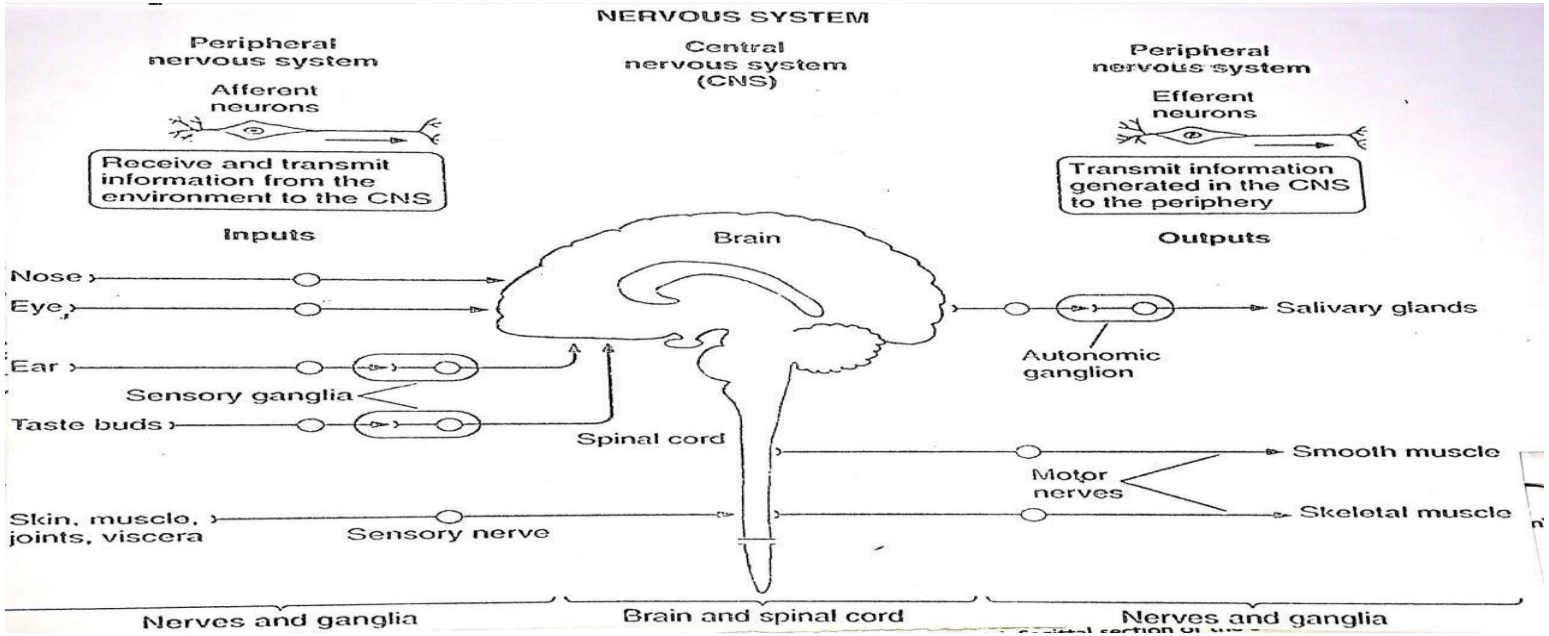
It is concerned mainly with detecting and responding to information from the internal environments.

Functional components of the nervous system

The neurons of either the somatic and visceral nervous system can be :

1. Afferent [latin ad-ferens = bringing to]
2. Efferent [latin ex-ferens = bringing from]

(figure 1)



Functional components of the nervous system

I. General components

A. Somatic

1. General somatic Afferent fibers(GSAs)

Carry general sensations (touch, pain , temperature and , position) from skin and joints to the CNS.

2. General somatic Efferent fibers (GSEs)

Carry motor fibers from CNS to skeletal muscles .

B. Visceral

1. General visceral Afferent fibers (GVAs)

Concerned with chemoreceptors and , mechanoreceptors

2. General visceral efferent fibers (GVEs) or [the Autonomic Nervous system (ANS)]

Innervation of smooth muscles and secretomotor to the glands.

Functional components of the nervous system

II. Special components

(in the head and neck)

A. Somatic

Special somatic Afferent fibers(SSAs)

a. For vision .

b. For hearing .

B. Visceral

1. Special visceral afferent fibers(SVAs)

a. For olfaction (smell)

b. For gustation (taste)

2. Special visceral efferent fibers (SVEs)

Motor fibers for branchial muscles .

(facial, mastication , pharyngeal)

The central Nervous system

Consists of

1. The Brain
2. The spinal cord

The Brain

It lies in the cranial cavity , is continuous with the spinal cord through the foramen magnum

Parts of the brain

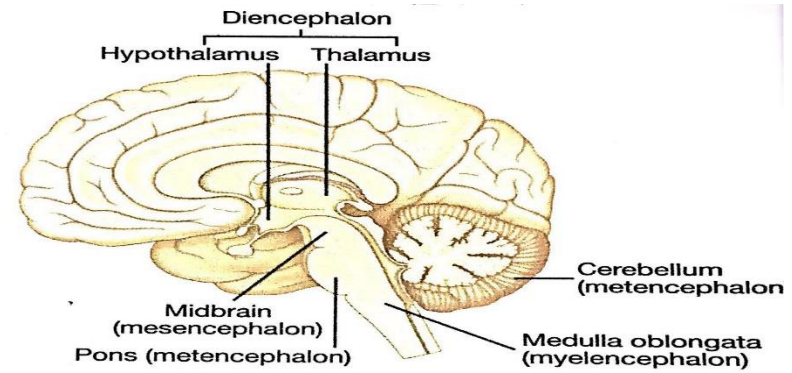
A. The cerebrum

B. The brainstem which consist of :

1. The midbrain
2. The pons
3. The medulla oblongata

C . The cerebellum

(fig 2)



Sagittal section of the brain.

The Brain

A. <u>The cerebrum</u>

- the largest part of the brain
- Composed of two cerebral hemispheres , connected by corpus collosum (a mass of white matter)
- **<u>The cerebrum consists of</u>**

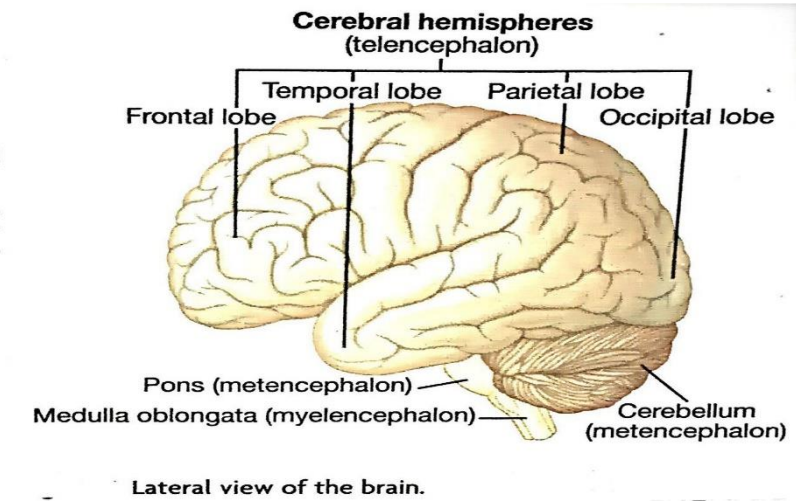
1. An outer portion : (the cortex) composed of gray matter containing cell bodies.
2. An inner portion : the (white matter) made up of myelinated axons forming tracts or pathways
3. Ventricles : which are spaces containing CSF (cerebrospinal fluid)

- Each cerebral hemisphere is subdivided into lobes which are named after the bones of the cranium under which they lie :

<u>The lobes are</u>

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

(fig 3)



Lateral view of the brain.

The Brain

B. **The brainstem**

Composed of three parts : the midbrain , the pons and the medulla oblongata .

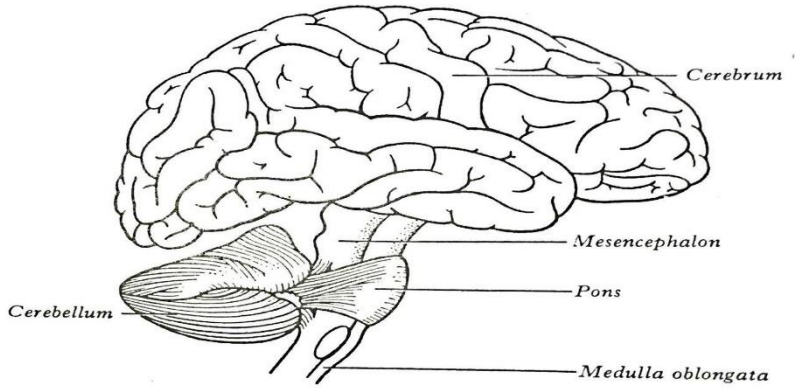
Composed :

1. Mainly of modulated nerve fibers forming ascending and descending tracts connecting the cortex of the brain with the lower centers and the spinal cord
2. ***Nuclei*** which are aggregations of cell bodies for relay stations or nuclie for cranial nerves

C. **The cerebellum**

- Lies within the posterior cranial fossa
- Consist of two hemispheres . Which an outer layer (the cortex) composed of gray matter containing nerve cells , and an inner layer of white matter composed of fibers connecting the cerebellum with other centers of the brain
- Cerebellum: control coordination and

muscle tone on the same side of the body.



Semi-diagrammatic scheme of the main divisions of the brain.

The meninges of the brain

The brain in the skull is surrounded by three protective coverings

1. **The Dura mater**

the outermost covering

- Tough connective tissue covering lining the interior of the skull
- Sends septae (falx cerebri , tentorium cerebelli help restrict displacement of the brain)

2. **The Arachnoid mater**

Delicate membrane attached loosely to the dura mater leaving a potential space : the subdural space . And separated from the pia matter by space called subarachnoid space which contains CSF.

3. **The pia matter**

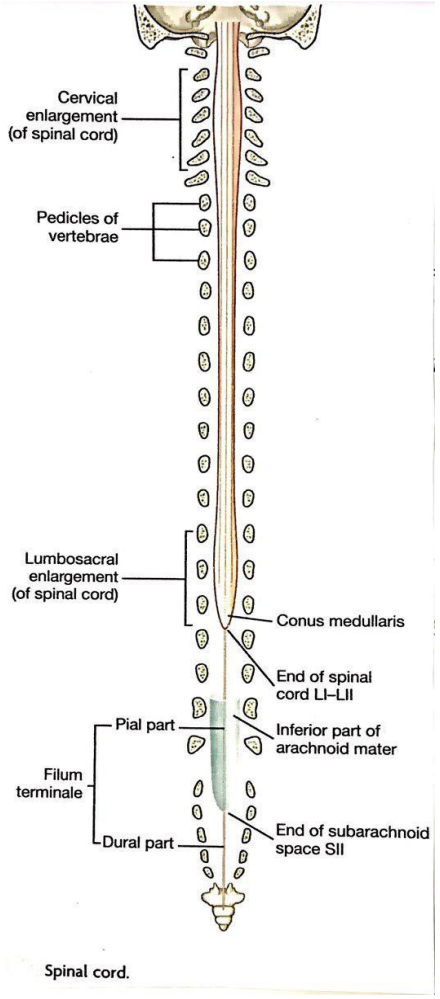
Vascular membrane closely invests the brain.

The central Nervous system (CNS)

The spinal cord

- Extends from the foramen magnum as a continuation of medulla oblongata of the brain
- Terminates inferiorly in the vertebral canal at the level between L1 and L2 vertebrae.
- It is a cylindrical greyish-white structure , measuring an average of 45cms in the adult . And of 30gm weight
- Inferiorly it tapers off into (conus medullaris) and from it's apex a prolongation of pia matter the (filum terminale)descends to be attached the coccyx
- The spinal canal has two enlargements :

1. Cervical enlargement : (for origins of C5 to T1) spinal nerves for upper limbs .
2. Lumbosacral enlargement (for origins of L1 to S3) spinal nerves for lumbosacral plexus which innervates.



Spinal cord.

The spinal Cord

The External surface

Is marked by

1. **The anterior median fissure**

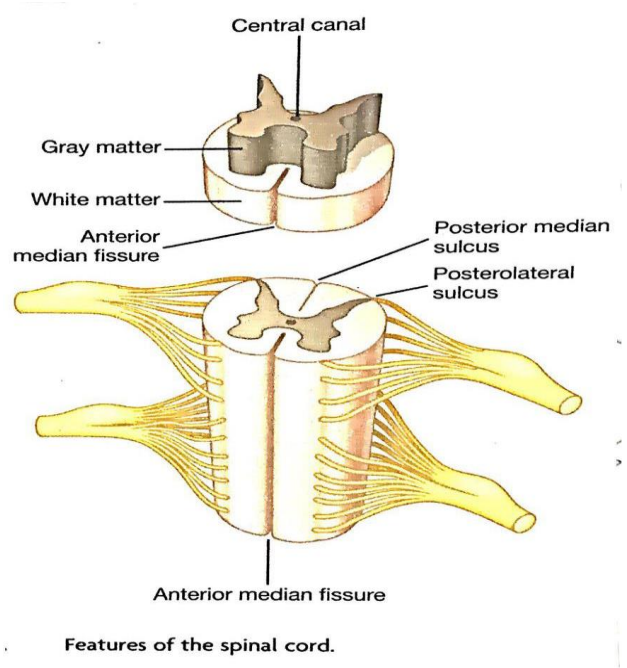
   Extends the length of the anterior surface

2. **The posterior median sulcus**

   Extends along the posterior surface

3. **The posterolateral sulcus**

One on each side of the posterior surface makes where the posterior rootlets of the spinal nerves enter the cord.



Features of the spinal cord.

The spinal cord

The interior of the cord

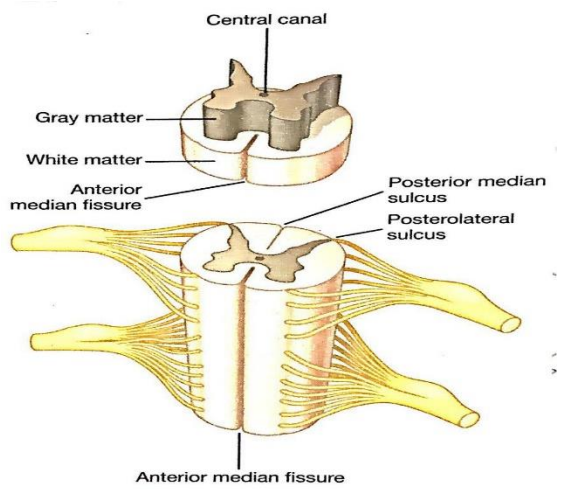
Features in a cross section

1. The central canal

Is surrounded by the gray and white matter

2. The gray matter

- Rich in nerve cells, and forms a characteristic H-shaped appearance in the central region.



Features of the spinal cord.

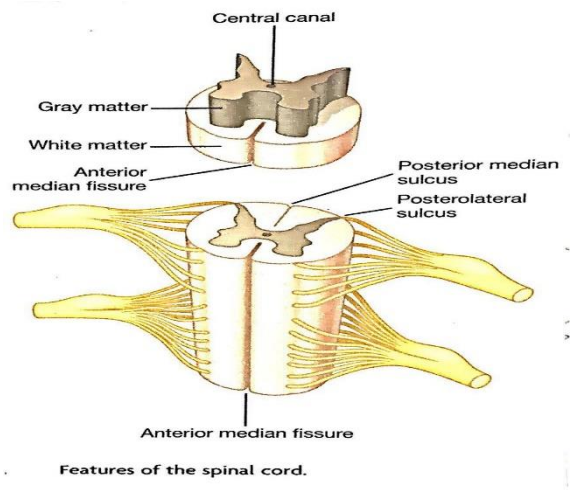
- Each arm of the (H) is called a (horn)
- The arms toward the back of the body are the posterior (dorsal) horns, which receive the terminal ends of the (afferent) sensory fibers of the spinal nerve
- The arms toward the front of the body are the anterior (ventral) horns, which have the cell bodies of the (Efferent) motor fibers that leave the spinal cord through the spinal nerves.

The spinal cord

features in a cross section

3. The white matter

- Peripherally situated , surrounds the gray matter
- Rich in myelinated nerve processes which form large bundles of tracts that ascend or descend to different levels of the spinal cord and to and from the higher centers in the brain



Features of the spinal cord.

The spinal card
the spinal meninges

Like the cranial meninges , there are three spinal meninges

1. **The Dura matter**

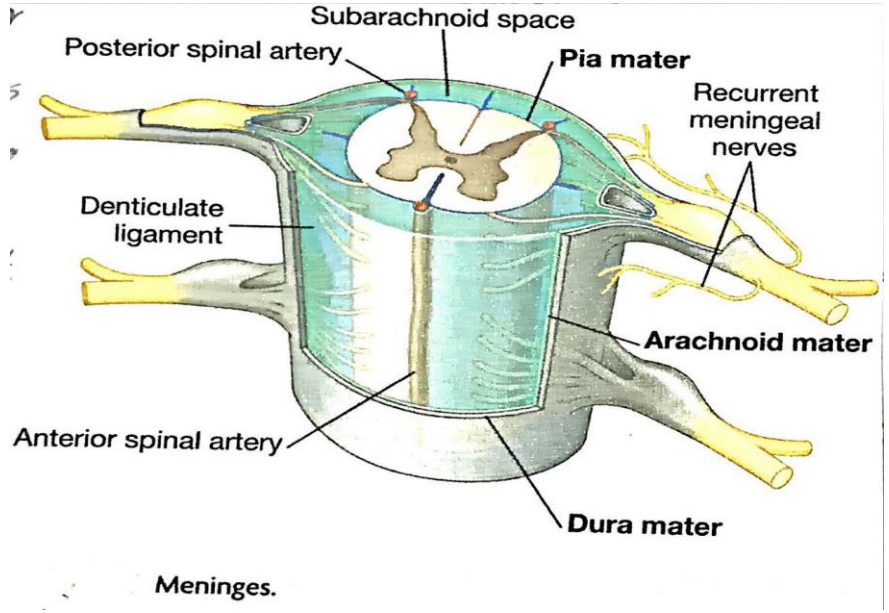
- Outer most covering
- Separated from bones of the vertebral column by the extradural (Epidural) space.
- Extends from the foramen magnum superiorly , ends inferiorly at the lower border of S2 vertebra

2. **The Arachnoid matter**

- A delicate membrane against the dura matter
- Separated from the pia matter by the (subarachnoid space) which contains CSF and cauda equina.
- Ends at the lower border of S2 vertebra

3. **The pia matter**

Is a vascular membrane , surrounds the spinal cord (fig 7)



Meninges.

The spinal cord

Arrangement of structures in the vertebral canal

Each spinal nerve is connected to the spinal cord by

1. Posterior root

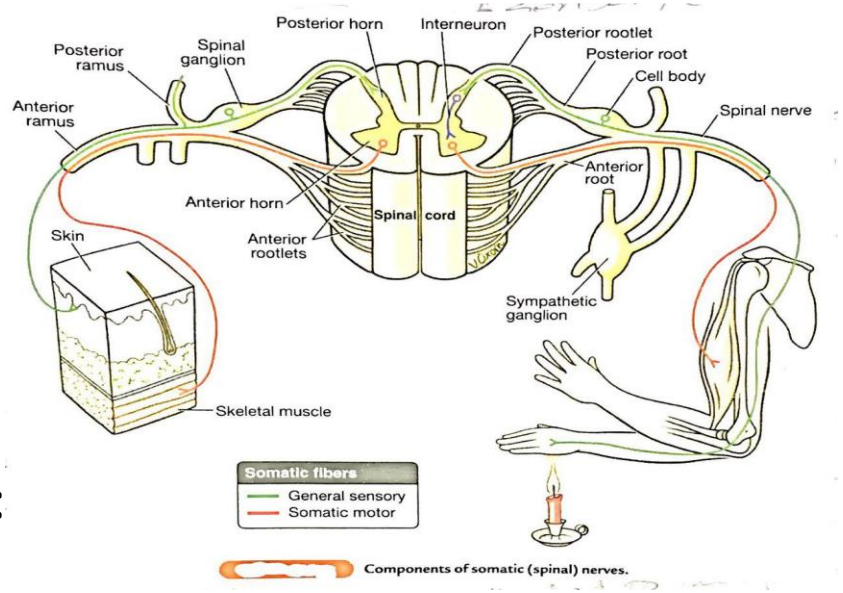
- Containing the processes of sensory (afferent) neurons carrying information to the CNS.
- The cell bodies of the sensory neurons , are clustered in a (spinal ganglion) at the distal end of the posterior root , in the intervertebral foramen.

2. Anterior root

- Contains motor (efferent) nerve fibers which carry signals away from the CNS
- The cell bodies of the primary motor neurons are in the anterior horn of the spinal cord

❖**Medially** : the posterior and anterior roots divide into rootlets which are attached to the spinal cord

❖**Laterally** : the posterior and anterior roots on each side : join to form a spinal nerve .



The spinal cord

Arrangement of structures in the vertebral canal

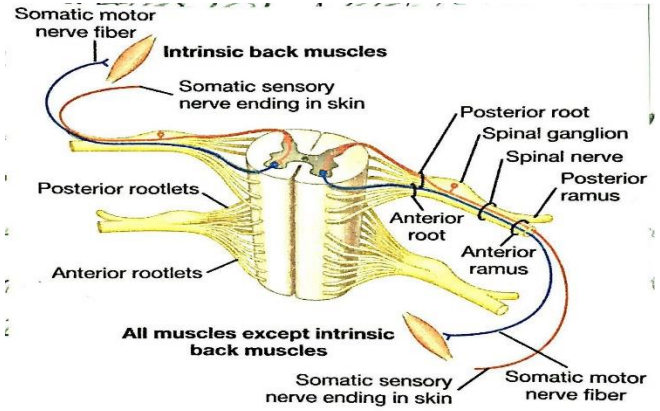
- The spinal cord (for descriptive purposes) is divided into regions named after the regions of the vertebral column into :

(cervical , thoracic , lumbar , sacral and , coccygeal)

- **The spinal segment**

Is the area of spinal cord that gives rise to the posterior and anterior rootlets which will form a single spinal nerve.

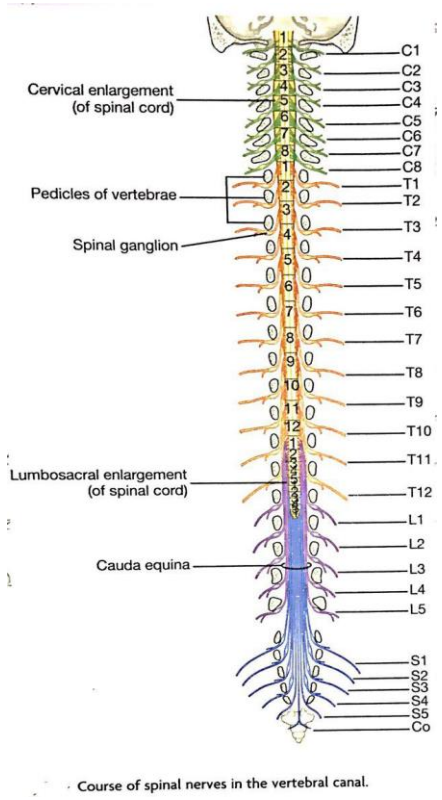
- Because the spinal cord is much shorter than the vertebral column , the roots of the spinal nerves become longer , and pass more obliquely from cervical to coccygeal regions of the vertebral Canal.



Basic organization of a spinal nerve.

The spinal cord

- In adult the spinal cord terminates at level of L1-l2 intervertebral disc
- Consequently :- posterior and anterior roots forming spinal nerves emerging between vertebrae in the lower regions of the vertebral column are connected to the spinal cord at higher levels.
- Below the end of the spinal cord , the posterior and anterior roots of the lumbar, sacral and, coccygeal nerves pass inferiorly to reach their exit points from the vertebral canal.
- This terminal cluster of roots is the(cauda equina)



Course of spinal nerves in the vertebral canal.

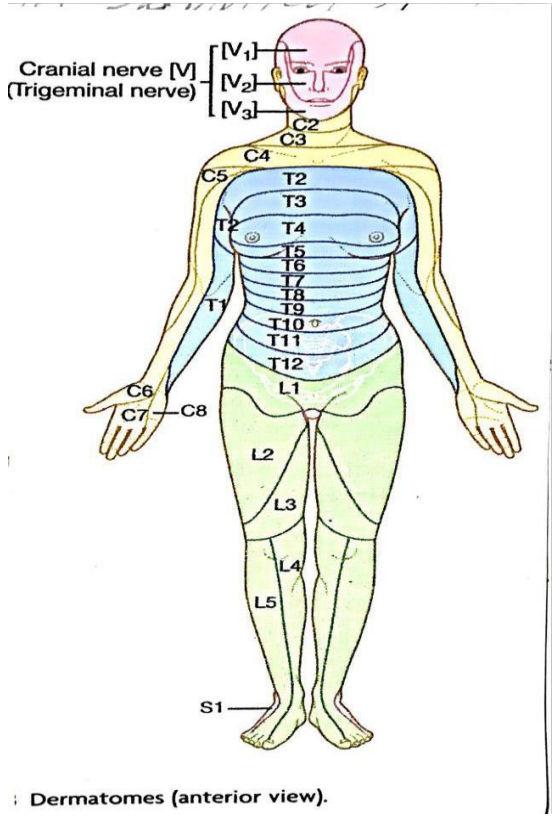
The spinal cord

A Dermatome

Is that area of skin supplied by a single spinal cord level , or one side by a single spinal nerve

A myotome

Is that portion of a skeletal muscle innervated by a single spinal cord level or , on one side by a single spinal nerve.



Dermatomes (anterior view).

The peripheral Nervous system [PNS]

Composed of spinal and cranial nerves and their associated ganglia

The spinal nerves

They are 31 pairs

8 cervical(C)

12 thoracic (T)

5 lumbar (L)

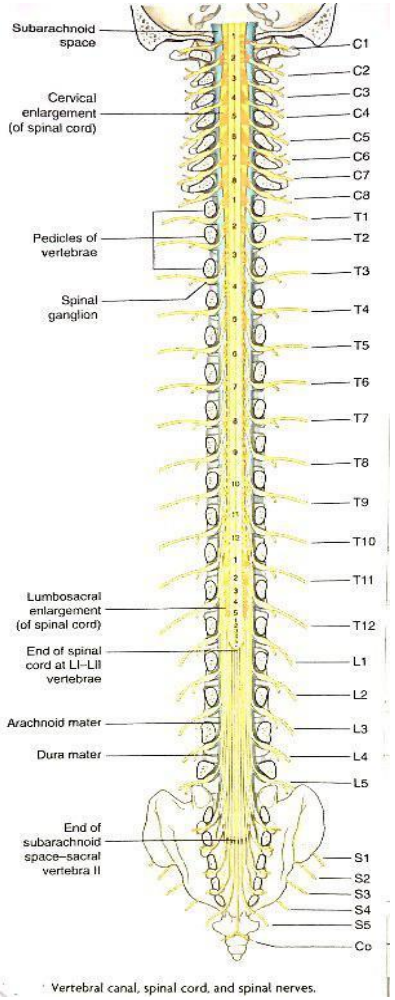
5 sacral (S)

1 coccygeal(co)

Based on their position to the vertebral column .

Their functional components are

1. General somatic afferents(GSA)
2. General somatic efferent(GSE)
3. General visceral afferents(GVA)
4. General visceral efferent (GVE)



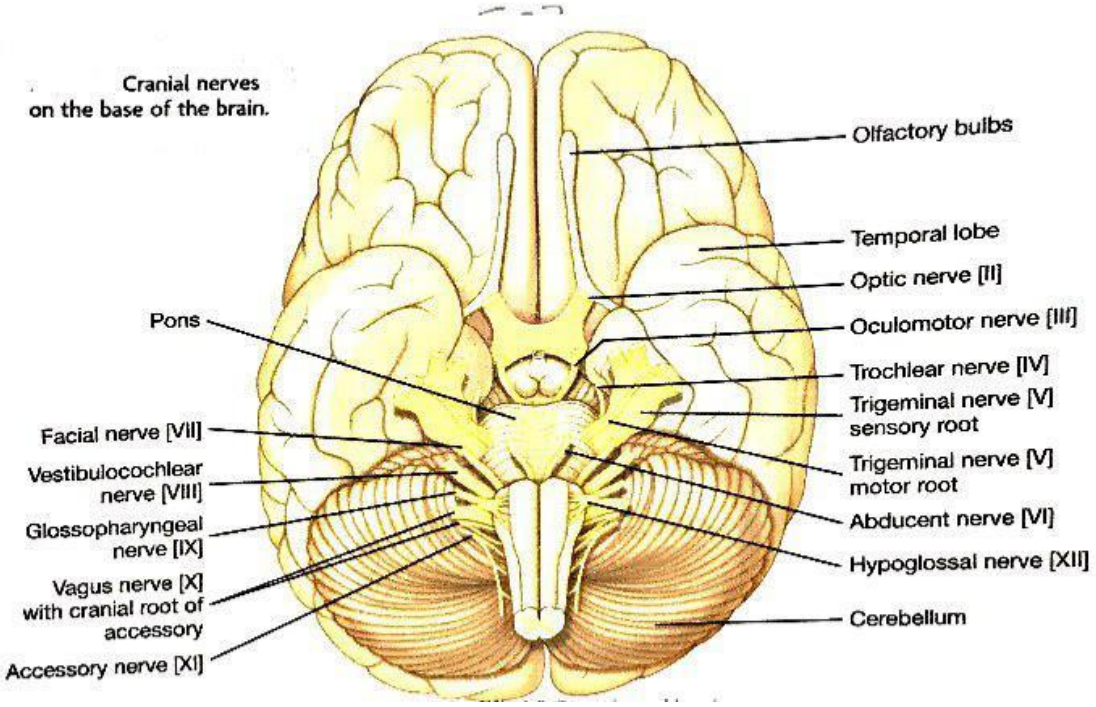
Vertebral canal, spinal cord, and spinal nerves.

The peripheral Nervous system [PNS]

The cranial nerves

- 12 pairs arise from the brain
- Some of the have special components in addition to the general components

1. The olfactory nerve [I]
   special sensation (the smell)
2. The optic nerve [II]
   special sensation(the vision)
3. The oculomotor nerve[III]
   general motor , and parasympathetic
4. The trochlear nerve[IV]
   general motor
5. The trigeminal nerve [V]
   general sensory and special motor
6. The abducent nerve[VI]
   general motor



The cranial nerves

7. The facial nerve [VII]
Special sensory (taste) special motor and parasympathetic
8. The vestibulochochlear [VIII]
Special sensory (hearing and balance)
9. The glossopharyngeal
Special sensory (taste) , special motor and parasympathetic
10. The vagus nerve[X]
Parasympathetic , special motor
11. The Accessory nerve [XI]
General sensory
12. The hypoglossal [XII]
General motor

The cranial nerves

Functional components

A. Special sensory

1.Smell : olfactory nerve[I]

2.Vision : optic nerve[II]

3.Hearing and balance : vestibulochochlear nerve[VIII]

4.Taste : facial nerve[VII] and glossopharyngeal nerve [IX]

B. General sensory

1.Trigeminal nerve[V]

2.Facial nerve[VII]

3.Glossopharyngeal nerve [IX]

4.Vagus nerve[X]

C. General motor

1.Oculomotor nerve[III]

2.Trochlear nerve[IV]

3.Abducent nerve [VI]

4.Accessory nerve[XI]

5-hypoglossal nerve[XII]

The cranial nerves

D**. Special motor**

1. Trigeminal nerve[V]
2. Facial nerve [VII]
3. Glossopharyngeal nerve[IX]
4. Vagus nerve[X]

E**. General visceral (parasympathetic)**

1. Oculomotor [III]
2. Facial nerve[VII]
3. Glossopharyngeal [IX]
4. Vagus nerve [X]

The visceral nervous system

Consist of two components :

A. <u>The visceral sensory component :</u>

The sensory(afferent)nerves monitor changes in the viscera

B<u>. The visceral motor component</u>

The motor nerves maily innervate smooth muscle, cardiac muscle , and glands

This component is commonly referred to as :

Autonomic nervous system (ANS)[I]

And is subdivided into

1.Sympathetic division

2.Parasympathetic division

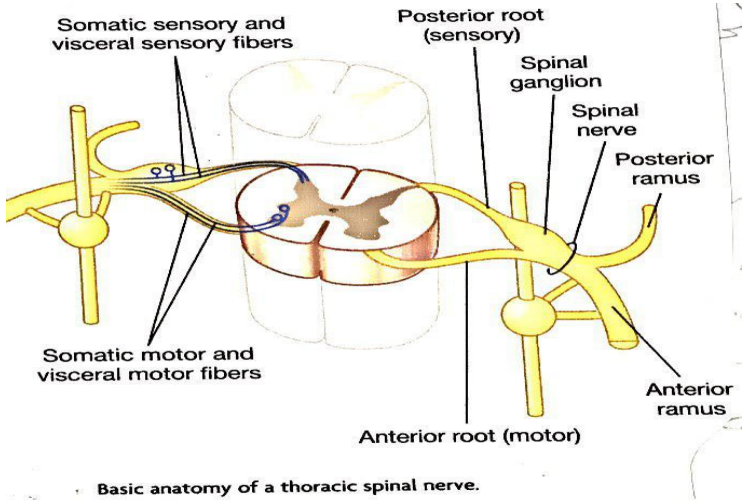
The Autonomic nervous system [ANS]

- The conduction of impulses from CNS to the effector organs involves a series of (two neurons) in both sympathetic and parasympathetic divisions.
- The body of the first neuron : the (connector neuron) or the (preganglionic neuron) is located in the grey matter of the CNS
- Its fiber (axon)synapses on the cell body of the second neuron (the postganglionic neuron)
- The cell bodies of the second neuron are

located in autonomic ganglia outside the CNS

- The postganglionic fibers terminate on the

effector organ (smooth muscle , cardiac muscle , or glands).



Basic anatomy of a thoracic spinal nerve.

The Autonomic nervous system [ANS]

The sympathetic nervous system

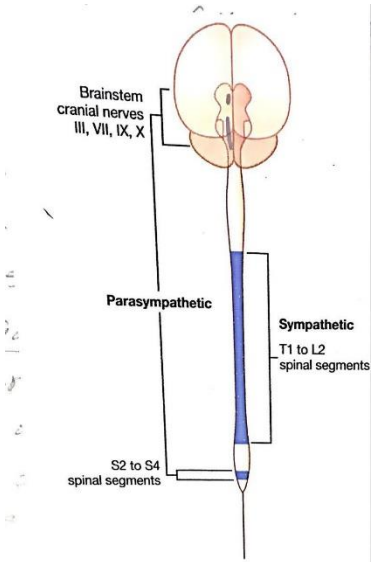
- The cell bodies of the (preganglionic neurons) of the sympathetic division of the (ANS) are located in the (lateral horn) part of grey matter extending between the first thoracic [T1] and the second lumbar [L2] segments of the spinal cord
- The cell bodies of (postganglionic neurons) of the sympathetic nervous system occur in two location :

1. **Paravertebral ganglia**

Are linked to form right and left (sympathetic trunk) on each side of the vertebral column extending from base of skull to the coccyx , where the two trunks unite at the ganglion impar.

2. **Prevertebral ganglia**

Are in the plexuses that surround the origins of the main branches of the abdominal aorta (e.g celiac ganglia).



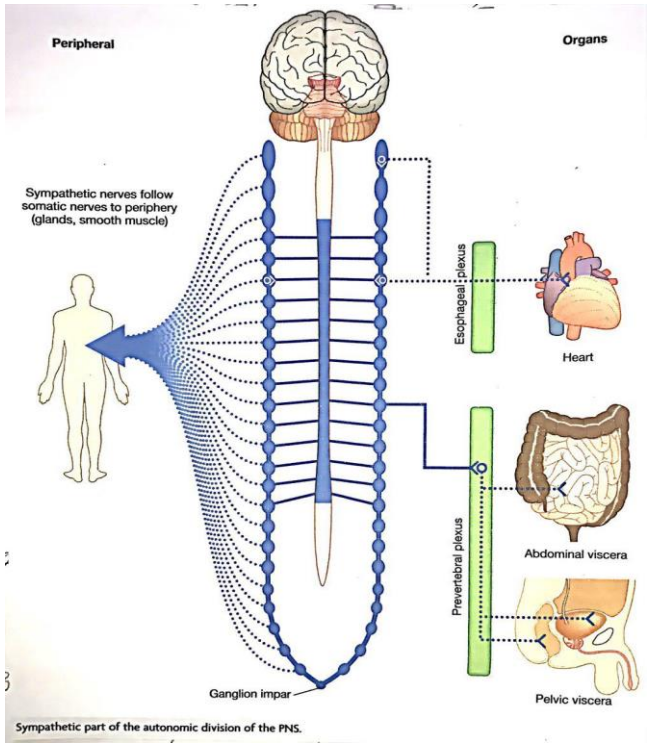
Parts of the CNS associated with visceral motor components.

The sympathetic nervous system

the motor fibers (axons)of the preganglionic neurons leave the spinal cord through the anterior roots to spinal nerves(anterior rami) pass to the sympathetic trunks, through (white rami communicantes)

Destinations of the preganglionic sympathetic fibers

1. Enter a ganglion at the same level , and synapse with postganglionic neuron
2. Ascend or descend in the sympathetic trunk to synapse with a postganglionic neuron of a higher or lower ganglion
3. Pass through sympathetic trunk without synapsing continuing on through an abdominopelvic splanchnic nerves to reach the prevertebral ganglia and synapse with a postganglionic neuron .



The sympathetic nervous system

The postganglionic sympathetic fibers

- They pass from the paravertebral ganglia of the sympathetic trunks to the adjacent anterior ramus of the spinal nerve through (gray rami communication)
- By these means they enter all branches of the 31 pairs of spinal nerves . or may form nerve plexuses branches of the carotid vessels in the head and neck
- **The splanchic nerves**

Conveys visceral efferent and afferent fibers from the viscera of the body cavities

The abdomino pelvic nerves are

1. Greater
2. Lesser
3. Least
4. Lumbar/ sacral splanchnic

All the preganglionic fibers in these nerves synapse in the prevertebral ganglia -→target organs

The sympathetic nervous system

The sympathetic trunks

Two ganglionated nerve trunks.

The paravertebral ganglia of the trunk.

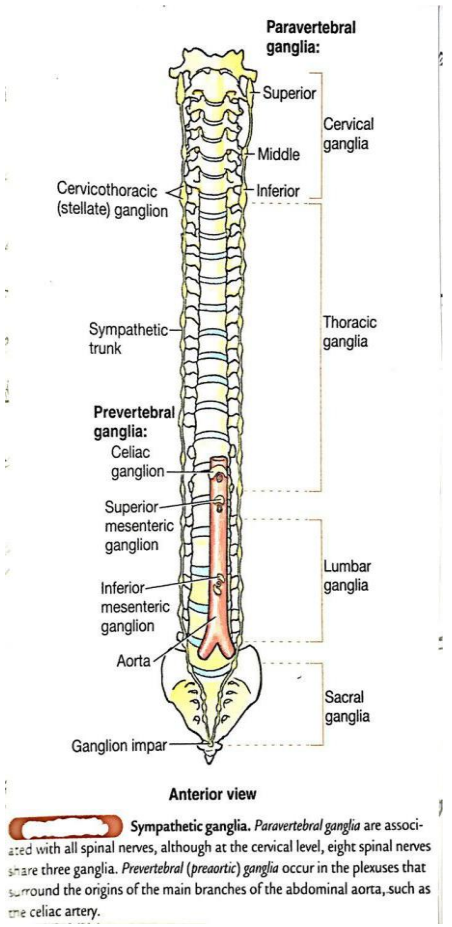
1. 3 ganglia in the neck

a. Superior cervical ganglion

b. Middle cervical ganglion

c. Inferior cervical ganglion : may fuse with the first thoracic ganglion to form the (stellate) ganglion

2. 11-12 ganglion in the thorax
3. 4-5 ganglion in the lumbar region
4. 4-5 ganglion in the pelvis
5. (ganglion impar) where the right and left trunks are close together and fuse to form this ganglion.



The parasympathetic nervous system

- The preganglionic parasympathetic neuron cell bodies are located in two sites (craniosacral)

The fibers exit the CNS within the following cranial nerves

1- cranial outflow:

The cell bodies are in the gray matter of the brainstem , the nerves are:

a) The oculomotor [III]

b) The facial nerve[VII]

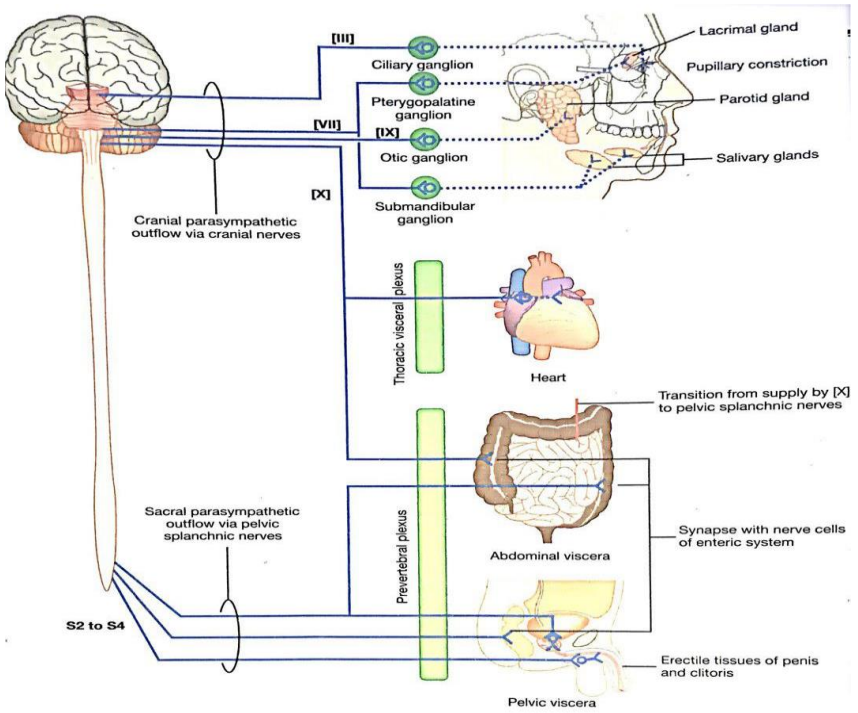
c) The glossopharyngeal nerve [IX]

d) The vagus nerve [X]

- These fibers constitute the (cranial parasympathetic out flow)
- 2- sacral outflow:

- The cell bodies are in the second to fourth sacral segments.
- The nerves are 2nd to 4th sacral nerves.

- These fibers constitute the (sacral parasympathetic outflow)
- The cranial outflow provides innervation to head and neck
- The vagus nerve [X] provides innervation to thoracic and most of the abdominal viscera.
- The sacral outflow provide innervation to pelvic viscera.



Parasympathetic part of the autonomic division of the PNS.

The parasympathetic nervous system

A. <u>The cranial parasympathetic ganglia</u>

1. <u>Ciliary ganglion</u> in the orbit preganglionic fibers exit with oculomotor nerve[III]

Postganglionic fibers cause : constriction of pupil

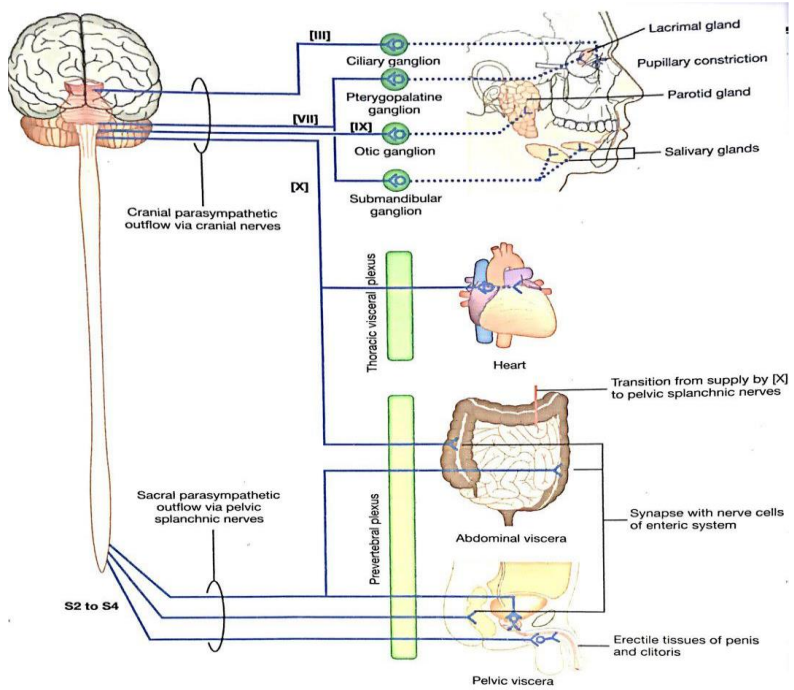
2. Pterygo palatine ganglion : in the pterygopalatine fossa preganglionic fibers with facial nerve : secretomotor to lacrimal gland , nose and palate and nasopharynx

3. Otic ganglion : in the infratemporal fossa preganglionic fibers exit with the glossopharyngeal nerve [IIX] secretomotor to parotid gland

4. Submandibular ganglion in the floor of the mouth preganglionic exit with the facial nerve [VII] secretomotor to glands in the mouth

3. **<u>The visceral ganglia</u>**

In plexus near the viscera or embed in the walls of the viscera (intrinsic or enteric ganglia).



Parasympathetic part of the autonomic division of the PNS.

The autonomic nervous system

The pre-and postganglionic fibers

- The sympathetic preganglionic fibers

Are usually short (CNS → paravertebral ganglia)

- The sympathetic postganglionic fibers

Are usually long

- The parasympathetic preganglionic fibers

Are usually long (CNS → prevertebral ganglia: are remote from CNS)

- The parasympathetic postganglionic fibers are short (the parasympathetic ganglia are close to the target organs)

Functions of the sympathetic nervous system

In general : the effects of sympathetic stimulation are catabolic preparing the body for emergency (flight-or-fight) response , expenditure of energy

Effect of sympathetic stimulation

1. Dilates pupils
2. a. vasoconstriction of peripheral blood vessels
   b. promote sweating
   c. cause skin hair Rostand on end (gooseflesh)
3. Decrease secretion of salivary and lacrimal glands
4. a. increase heart rate
   b. increase strength of contraction of cardiac muscles
   c. dilatation of coronary vessels by inhibiting the parasympathetic effect
5. Bronchodilatation , reduction of bronchial secretion by inhibiting the parasympathetic effect
6. a. inhibit peristalsis
   b. constriction of GIT vessels to divert blood to skeletal muscles
   c. contracts the internal anal sphincter
7. a. slow urine formation by constricting renal blood vessels
   b. contracts the internal sphincter of the bladder
8. Promote breakdown of glycogen to glucose (increase energy)
9. Release adrenaline into blood

Functions of the parasympathetic nervous system

In general the effects of parasympathetic stimulation are anabolic , promoting normal function and conserving energy

Effect of parasympathetic stimulation

1. a. constrict pupils.
   b. contraction of ciliary muscles → accommodation for near vision .
2. Promote secretion of lacrimal and salivary glands \
3. a. decrease heart rate
   b. decrease strength of contraction of cardiac muscles
   c. constrict coronary vessels (reduced demand)
4. a. constrict bronchi
   b. promote bronchial secretion
5. a. stimulate peristalsis
   b. stimulate secretion of digestive juices
   c. inhibit internal anal sphincter → defecation
6. a. inhibits contraction of internal sphincter of the bladder
   b. promote contraction of detrusor muscle of the bladder → urination
7. Promote building / conservation of glycogen

Neurotransmitters

- A functional distinction of pharmacological importance in medical practice , is that the postganglionic neurons of the two divisions of the autonomic nervous system , generally liberate different neurotransmitter substances :

1. Noradrenaline : by the sympathetic division (adrenergic) [except in the case of sweat glands : acetylcholine]
2. Acetylcholine : by the parasympathetic division (cholinergic)

- ***THANKS***