**Introduction and Basic structural organization of the nervous system**

**INTRODUCTION**
- The nervous system, along with the endocrine system, helps to keep controlled conditions within limits that maintain health and helps to maintain homeostasis.
- The nervous system is responsible for all our behaviors, memories, and movements.
- The branch of medical science that deals with the normal functioning and disorders of the nervous system is called neurology.

The NS control other systems either indirectly through endocrine or directly through controlling muscles and contraction, NS also have other functions like controlling behavior and memory etc.. The NS is a complex integration of information and depending on it the decision is made.

**Enteric NS** → It is capable of acting independent of the sympathetic and parasympathetic nervous systems, although it may be influenced by them. The ENS is also called the second brain, capable of autonomous functions like the coordination of reflexes; although it receives considerable innervation from the autonomic nervous system.
• CNS
• Brain and Spinal Cord
• PNS
  • cranial nerves, spinal nerves, ganglia, enteric plexuses and sensory receptors

Nervous System Divisions
• Central nervous system (CNS)
• consists of the brain and spinal cord
• Peripheral nervous system (PNS)
• consists of cranial and spinal nerves that contain both sensory and motor fibers
• connects CNS to muscles, glands & all sensory receptors

The nervous system is divided into two main parts:
→ the central nervous system, which consists of the brain and spinal cord, and the peripheral nervous system, which consists of 12 pairs of cranial nerves and 31 pairs of spinal nerves and their associated ganglia.
→ Functionally, the nervous system can be further divided into the somatic nervous system, which controls voluntary activities & innervates skin and skeletal muscles and the autonomic nervous system, which controls involuntary activities & innervates organ system in the body and other visceral elements such as glands and smooth muscles

Functions of the Nervous Systems
• The sensory function of the nervous system is to sense changes in the internal and external environment through sensory receptors.
  • Sensory (afferent) neurons serve this function.
• The integrative function is to analyze the sensory information, store some aspects, and make decisions regarding appropriate behaviors.
  • Association or interneurons serve this function.
• The motor function is to respond to stimuli by initiating action.
  • Motor(efferent) neurons serve this function

We have 2 function for the PNS:
* Sensory → transfer info/data/stimuli from the skin towards the CNS
  Mechanical                 visual                    temperature

*Motor & 1 function for the CNS → integrate sensory info and analyze data and depending on that data decision making occur.

If sensory part is cut the transmission of the sensory info is interrupted so feeling is obscured.
If the damage occur in the CNS the info is transmitted but the analysis doesn’t take place.
If the damage is in the integration center reflex can occur but the feeling is lost.
If motor is damaged reflex doesn’t occur.
Subdivisions of the PNS
→ Somatic (voluntary) nervous system (SNS)
  • neurons from cutaneous and special sensory receptors to the CNS
  • motor neurons to skeletal muscle tissue
→ Autonomic (involuntary) nervous systems
  • sensory neurons from visceral organs to CNS
  • motor neurons to smooth & cardiac muscle and glands
  • sympathetic division (speeds up heart rate)
  • parasympathetic division (slow down heart rate)

Afferent division of PNS
\[
\begin{align*}
\text{Somatic} & : \text{sensation from the skin mostly} \\
\text{Autonomic} & : \text{blood vessel and visceral organs}
\end{align*}
\]

Efferent division of PNS
\[
\begin{align*}
\text{Somatic} & : \text{target skeletal muscles} \\
\text{Autonomic} & : \text{target cardiac and smooth muscles}
\end{align*}
\]

Gray and White Matter
• White matter = myelinated processes (white in color)
• Gray matter = nerve cell bodies, dendrites, axon terminals, bundles of unmyelinated axons and neuroglia (gray color)
• In the spinal cord = gray matter forms an H-shaped inner core surrounded by white matter
• In the brain = a thin outer shell of gray matter covers the surface & is found in clusters called nuclei inside the CNS
Grey matter: - cell bodies - peripheral in the brain and central in the spinal cord

Distribution of neurons

White matter: - axons of neurons
- High concentration of fat (white color)
- Centrally in the brain and peripheral in the spinal cord

In the brain we have islets of grey matter within the white matter

The Spinal Cord & Spinal Nerves
- Together with brain forms the CNS
- Functions
- spinal cord reflexes
- integration (summation of inhibitory and excitatory) nerve impulses
- highway for upward and downward travel of sensory and motor information.

Spinal Cord Protection

By the vertebral column, meninges, cerebrospinal fluid, and vertebral ligament
Structures Covering the Spinal Cord

- **Bones (Vertebrae)**

  - Epidural space filled with fat: b/w vertebrae and dura mater and is absent in brain meninges which means the dura mater in the brain is directly attaches to the cranial bones.

- **Meninges**

  - Dura mater
    - dense irregular CT tube
      - Outer most layer, separated from the bone forming the vertebral Canal by epidural space.
      - It is continuous superiorly through the foramen magnum with the meningeal layer of dura covering the brain. Inferiorly, it ends on the filum terminale at the level of the lower border of the second sacral vertebra.

  - **Subdural space filled with interstitial fluid**: b/w the dura mater and arachnoid mater; is a potential space because dura mater in in close contact with arachnoid mater but is not directly attached to it.

  - Arachnoid = spider web of collagen fibers lying between the pia mater internally and the dura mater externally. The arachnoid is continuous above through the foramen magnum with the arachnoid covering the brain. Inferiorly, it ends on the filum terminale at the level of the lower border of the second sacral vertebra.

  - **Subarachnoid space = CSF**: b/w arachnoid mater and pia mater and extend farther inferiorly than the SC, the SC ends at approximately the disc b/w vertebrae L1-L2 whereas subarachnoid space extend approximately the lower border of S2.

  - Pia mater is a vascular membrane that closely covers the spinal cord.

    - thin layer covers BV
    - denticulate ligs hold in place

      - It is continuous superiorly through the foramen magnum with the pia covering the brain; inferiorly, it fuses with the filum terminale.
      - The pia mater is thickened on either side between the nerve roots to form the ligamentum denticulatum, which passes laterally to be attached to the dura.
      - The ligament function to position the SC in the center of subarachnoid space.

      - **at certain point the pia mater and arachnoid membrane are separated by wide intervals which communicate freely with each other known as subarachnoid cisterns; we will talk about it later.**
Gray Matter of the Spinal Cord

- Gray matter is shaped like the letter H or a butterfly
- Contains neuron cell bodies, unmyelinated axons & dendrites
- Paired dorsal and ventral gray horns
- Lateral horns only present in thoracic spinal cord
- Gray commissure crosses the midline \(\rightarrow\) connection b/w left and right
- Central canal continuous with 4th ventricle of brain

Ventral horn :- cell bodies of somatic motor neurons

Lateral horn :- cell bodies of autonomic motor neurons

Posteriorly : interneuron responsible for receiving info from sensory

** Every neuron has cell body, dendrite, and axon which often gives off one or more collateral branches that lead to other and making network of the circuit

White Matter of the Spinal Cord
White matter covers gray matter
- Anterior median fissure deeper than Posterior median sulcus
- Anterior, Lateral and Posterior White Columns contain axons that form ascending & descending tracts
*white matter : is a collection of axons or bundles known as fasciculi or tract
*Anteriorly, right and left sides in white matter are separated by anterior median fissure. Posteriorly by posterior median sulcus

Spinal Nerves
- 31 Pairs of spinal nerves
- Named & numbered by the cord level of their origin
- 8 pairs of cervical nerves
- 12 pairs of thoracic nerves
- 5 pairs of lumbar nerves
- 5 pairs of sacral nerves
- 1 pair of coccygeal nerves
- Mixed sensory & motor nerves
*one on each side of the vertebral column

Why do we have c8 spinal nerve? The spinal nerves exit the cervical spine above their corresponding vertebral body level. For example, the C7 nerve root exits above C7 through the C6-C7 neural foramen. C8 exits in between T1 and C7, since there is no C8 vertebral body level. This orientation is reversed in the thoracic and lumbar spine.

The Brain and Cranial Nerves
Principal Parts of the Brain

- **Cerebrum**: structurally is an external part of the brain and control voluntary function and is the seat of intelligence, memory, learning and thinking.
- **Cerebral hemispheres** → right and left and are partially separated by a deep longitudinal fissure so we can differentiate the 2 hemisphere superiorly
- **Corpus callosum** → white matter that connect the left and right sides of the brain allowing communication b/w both hemispheres so at the level of the corpus callosum we can't differentiate between the 2 hemispheres.

- **Diencephalon**
  - thalamus, hypothalamus, &epithalamus & is internal to the cerebrum

- **Cerebellum** → posterior to the brain stem and inferior to the cerebrum and receives info from the sensory system

- **Brainstem** → the midbrain (most rostral part of the brainstem), pons and medulla oblongata connects the brain to the spinal cord

- **medulla, pons & midbrain**
CT scan gives good info in bone windows but MRI gives clearer brain image

Protective Coverings of the Brain

- Bone, meninges & fluid
- Meninges same as around the spinal cord
- dura mater
- arachnoid mater
- pia mater
- Dura mater extensions
- falx cerebri
- tentorium cerebelli
- falx cerebella
Ventricles → are communication network of cavities filled with CSF

- 2 lateral ventricles, one within each cerebral hemisphere → C-shaped within the cerebrum structure.
- 3rd ventricle → connect 2 lateral ventricles and continues with the 4th ventricle.
- fourth ventricle

Ventricles

- Choroid plexus = capillaries covered by ependymal cells
- Production CSF
Cranial Nerves
- The cranial nerves are part of the peripheral nervous system
- There are 12 pairs of Cranial nerves
- All cranial nerves travel through foramina of the skull
- 10 pairs originate from the brain stem (III-XII)
- The cranial nerves are designated by:
  - Roman numerals which indicate the order in which the nerves arise from the brain from anterior to posterior
  - Names which indicate the distribution or function

Cranial Nerves
- Two cranial nerves (I and II) contain only sensory fibers and are therefore called sensory nerves
- The other cranial nerves contain both sensory and motor fibers and are therefore called mixed nerves
- Some of the mixed nerves are primarily motor in function (but contain proprioceptive fibers).
- The cell bodies of sensory fibers are located in ganglia outside the brain.
- The cell bodies of motor fibers are located in nuclei within the brain
- Some cranial nerves include both somatic motor and parasympathetic fibers of the autonomic nervous system.

U can just read the rest of the slides cuz the doctor just ran through them very quickly

Cranial Nerves: Types of Fibers

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
<th>Letter Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Afferent Fibers</strong></td>
<td>Sensory</td>
<td></td>
</tr>
<tr>
<td>General somatic afferent</td>
<td>General sensations</td>
<td>GSA</td>
</tr>
<tr>
<td>Special somatic afferent</td>
<td>Hearing, balance, vision</td>
<td>SSA</td>
</tr>
<tr>
<td>General visceral afferent</td>
<td>Viscera</td>
<td>GVA</td>
</tr>
<tr>
<td>Special visceral afferent</td>
<td>Smell, taste</td>
<td>SVA</td>
</tr>
<tr>
<td><strong>Efferent Fibers</strong></td>
<td>Somatic striated muscles</td>
<td></td>
</tr>
<tr>
<td>General somatic efferent</td>
<td>GSE</td>
<td></td>
</tr>
<tr>
<td>General visceral efferent</td>
<td>Glands and smooth muscles</td>
<td></td>
</tr>
<tr>
<td>Special visceral efferent</td>
<td>(parasympathetic innervation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Branchial arch striated muscles</td>
<td>SVE</td>
</tr>
</tbody>
</table>

Cranial Nerves

Ganglia Vs. Nuclei
- Both are clusters of neurons to form functional unit
- Nuclei in CNS
- Ganglia in PNS
- Sensory ganglia (DRG)
- Autonomic ganglia
Fasciculi, Lemnisci, & Tracts

- All are bundles of nerve fibers in the CNS
- Lemniscus is a bundle of nerve fibers of second order sensory neurons
- Medial & lateral lemnisci
- Tracts or fasciculi
- Gracile & cuneate fascicule

- Ascending and descending tracts
Afferent Vs. Efferent

- PNS
- Afferent – Sensory fibers
- Efferent – Motor fibers
- SC
- Afferent – Ascending tracts
- Efferent – Descending tracts
- Brain parts
- Afferent – Inputs
- Efferent – Outputs

Laminae
- Thin plates or layers of the gray matter of CNS
- Laminae of cerebral cortex
- Rexed laminae of spinal cord