Nervous Tissue and Histology of CNS
Functions of Nervous System

• Like the CPU of a computer, the nervous system is the *master controlling system* of the body.

• It is designed to constantly and rapidly adjust and respond to stimuli the body receives.

• It includes the brain, spinal cord, cranial nerves, and associated peripheral nerves.
Organization of the Nervous System

Two main divisions:

- **The Central Nervous System (CNS)**
  - Consists of the brain and spinal cord with tracts and nuclei
  
  **Nucleus** = a collection of nerve cell bodies in the CNS.
  
  **Tract** = bundle of nerve fibers within the CNS

- **The Peripheral Nervous System (PNS)**
  - Consists of ganglia, cranial nerves, spinal nerves and peripheral receptors

  **Ganglia** = a collection of nerve cell bodies in the PNS

  **Nerve** = bundle of nerve fibers in the PNS
Organization of the Nervous System

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Sensory or Afferent Division

- **Somatic sensory** = senses touch, pressure, pain, temperature, vibration and proprioception in skin, body wall and limbs.

- **Visceral sensory** = Autonomic sensory division - senses stretch, pain, temperature, chemical changes and irritation in viscera; nausea and hunger.
Motor or Efferent Division

- **Somatic motor**
  - A motor control to all skeletal muscles

- **Visceral Motor** = Autonomic Nervous System
  - A motor response that conducts impulses to smooth muscle, cardiac muscle and/or glands for appropriate response
Autonomic Nervous System

• Two divisions of ANS
  • Sympathetic division – Fight or Flight
  • Parasympathetic division – Food or Sex
Functional Organization of the Nervous System

Nervous system

Sensory (afferent) division
- Transmits information from periphery to the CNS
- Contains receptors
  - Somatic sensory
    - Receives sensory information from skin, fascia, joints, skeletal muscles, special senses
  - Visceral sensory
    - Receives sensory information from viscera

Motor (efferent) division
- Transmits information from CNS to the rest of the body
- Sends motor information to effectors
  - Somatic motor
    - “Voluntary” nervous system: innervates skeletal muscle
  - Autonomic motor
    - “Involuntary” nervous system: innervates cardiac muscle, smooth muscle, glands
Nervous System Histology

• Composed of:
  – **Neurons** are true conducting cells in nervous tissue
  – Neuroglial (supporting) cells
    - **CNS**
      - Astrocytes
      - Oligodendrocytes
      - Ependymal cells
      - Microglia
    - **PNS**
      - Schwann cells
      - Satellite cells
Neuron – nerve cell proper

- Structural and functional unit of Nervous System
- Consists of:
  - **body** – soma/pericaryon
  - **processes** - axon (away from the soma)
    - dendrites (to the soma)
Properties of Neurons

1. **Excitability** (irritability): ability to respond to environmental changes or stimuli.

2. **Conductivity**: respond to stimuli by initiating electrical signals that travel quickly to other cells at distant locations.

3. **Secretion**: Upon arrival of the impulse at a distant location the neuron usually secretes a chemical neurotransmitter at a synapse that crosses the synaptic gap and stimulates the next cell.
Neuron Structure

- **Nissl Bodies** – basophilic RER-associated polyribosomes in the pericaryon and bases of dendrites, absent in the axon hillock (part of the soma leading into the axon)

- **Axon**
  - single
  - Thin, less branches
  - Carries impulse away from the soma

- **Dendrites**
  - Carries impulse to the soma
  - Thick and branching
  - Number is different
Nissl Bodies
Cell body of neuron

Neurofibrils: aggregates of microfilaments and microtubules.
Structural Classification of Neurons

- Neurons may be:
  - Multipolar
  - Bipolar
  - Pseudounipolar

- Determined by the number of processes attached to the cell body
Neurons

• Most (99%) neurons in the body are multipolar (motor).

• Bipolar neurons are rare and occur in special sense organs of ear, nose and eye.

• Unipolar neurons begin as bipolar but processes fuse into one. They are primarily sensory neurons.
  • ex. dorsal root ganglion
Functional Classes of Neurons

- **Sensory (afferent) neurons** – afferent neurons are specialized to detect stimuli and transmit the information to CNS. They begin in any organ in the body, but end in the brain or spinal cord.

- **Interneurons (association neurons)**: lie entirely in the CNS. They receive signals from many different neurons and perform an integrative function “decision making” to respond to the different stimuli.

- **Motor (efferent) neurons** – efferent neurons transmit the appropriate response from the interneuron to an end organ (muscle and gland cells) to carry out the body’s response to the stimuli.
Functional Classification of Neurons

- Based on the direction of conduction
  - Sensory or afferent conduct toward the CNS
  - Motor or efferent conduct away from the CNS
  - Interneuron interposed between sensory and motor
Neuroglia cells

- Found in CNS and PNS
- Perform a supporting function for neurons

<table>
<thead>
<tr>
<th>CNS</th>
<th>PNS</th>
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<tbody>
<tr>
<td>Oligodendrocytes</td>
<td>Schwann cells</td>
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<tr>
<td>Astrocytes</td>
<td>Satellite cells</td>
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<tr>
<td>Ependymal cells</td>
<td></td>
</tr>
<tr>
<td>Microglial cells</td>
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</tbody>
</table>
Astrocytes - CNS

✓ Star shaped
✓ Most numerous
✓ Blood brain barrier

(a) Astrocytes are the most abundant CNS neuroglia.
Astrocytes
Astrocyte
Blood-BRAIN Barrier

=  

Endothelial cell

+  

BM

+  

Astrocyte foot process
Astrocytes contacting capillaries
Oligodendrocytes - CNS

- Form myelin sheath in CNS
- Fewer branches than astrocytes
Myelin

- Insulating layer around a nerve
- Formed by \textit{oligodendrocytes} in \textit{CNS} and \textit{Schwann cells} in \textit{PNS}
- Composed of a lipoprotein with phospholipids, glycolipids and cholesterol
- \textbf{Nodes of Ranvier} – gaps between myelin sheath
- The impulse jumps from Node to Node - \textit{Saltatory conduction}
- Myelin allows nerve conduction to be 150 x faster than in unmyelinated nerves
Myelin formation

1. Neurolemmocyte starts to wrap around a portion of an axon.


3. The overlapping inner layers of the plasma membrane form the myelin sheath.

4. The neurolemmocyte cytoplasm and nucleus are pushed to the periphery of the cell as the myelin sheath is formed.
Myelination of a peripheral axon
Myelin and Unmyelinated fibers
Ependymal cells - CNS

- Epithelial cells that line ventricles and central cavities of brain and spinal cord
- Take part in CSF secretion
- Ciliated to help circulate CSF
Cilia on the surface of ependymal cells
Microglia - CNS

- Thorny bushes in appearance and the smallest glia
- Phagocytic function in CNS
- Originate from monocytes
Satellite cells - PNS

- Surround neuron cell bodies within ganglia
- Provide nutrients, remove metabolites etc.

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Nerve structure

- Nerves are only on the periphery
- Cable-like organs in PNS = cranial and spinal nerves
- Consists of 100’s to 100,000’s of myelinated and unmyelinated axons (nerve fibers).
- Axons are grouped into bundles or fascicles
- **Endoneurium** surrounds each axon (nerve fiber).
- **Perineurium** surrounds each fascicle
- **Epineurium** surrounds each nerve
(a) Transverse section showing the coverings of a spinal nerve
(b) Transverse section of 12 nerve fascicles

13.10b
Nerve fibers

Two types:
- myelinated
- umyelinated
Myelinated axon

Unmyelinated axon
Synapse

The connection between 2 or more neurons or between a neuron and a target cell by which stimuli are transmitted.
Synaptic terminology

- **Presynaptic membrane** – part of the terminal button of the neuron that is conducting information toward the next neuron

- **Postsynaptic membrane** – thickening of the plasma membrane of the target neuron or cell, contains receptors to neurotransmitters

- **Synaptic cleft** – a fluid filled space into which the neurotransmitter is released

- **Most synaptic communication is via chemical messengers** (e.g. acetylcholine, GABA, glycine, glutamic acid, etc.)
Types of synapses

(c) Types of synapses
Axonal regeneration

- Nerve tracts in the CNS are incapable of regeneration on their own and there may be hope for stem cells carrying out this process.

- In the PNS, nerves can regenerate but very slowly and under only ideal conditions. Regeneration is dependent on 3 things:
  a) Amount of damage
  b) Schwan cell secretion of nerve growth factor
  c) The distance from the site of the damage to the end organ being reinnervated

- Regeneration occurs at a rate of ~ 1 to 5 mm/day.
Neuronal regeneration in the PNS

1. The axon is severed.

2. The proximal portion of the severed axon seals off and swells; the distal portion degenerates.

3. Neurolemmocytes form a regeneration tube.

4. Axon regenerates and remyelination occurs.

5. Reinnervation of the effector (skeletal muscle fibers) by the axon.
Christopher Reeve an American actor, best known for his motion picture portrayal of superhero Superman. Reeve became a quadriplegic after a severe spinal cord injury. He was confined to a wheelchair and required a portable ventilator for the rest of his life. Never the less, he lobbied on behalf of people with spinal cord injuries and for human embryonic stem cell research, founding the Christopher Reeve Foundation and co-founding the Reeve-Irvine Research Center.

But maybe in the not too distant future stem cells will lead to a partial cure of such patients.
Thank you for attention