Cells

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Review Sessions

with Dr. Riedl
Tuesdays
4-5pm
in MCB 3-146
(the main lab room)

The first exam is coming soon!

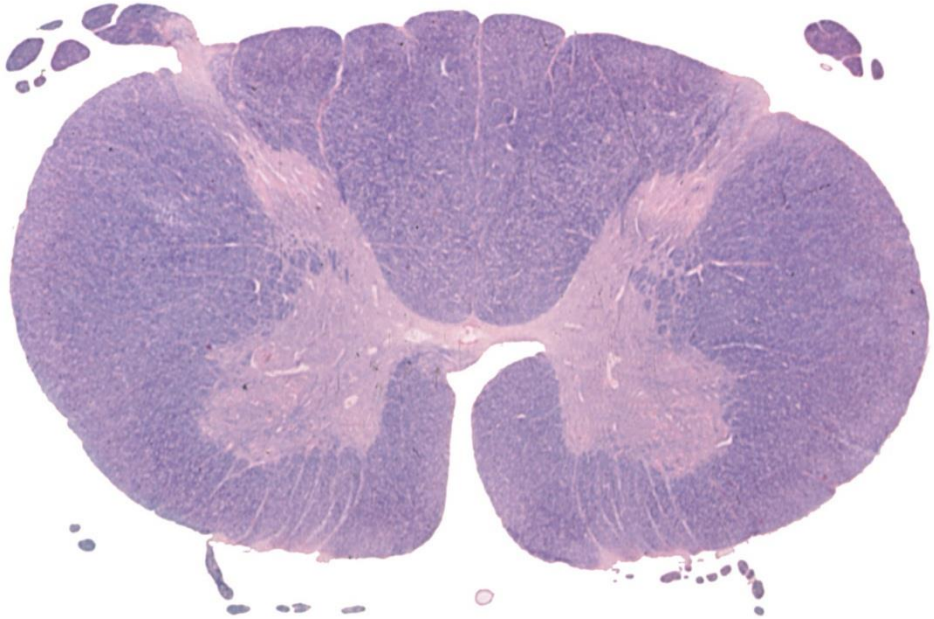
Microscopy

Methods of histology:

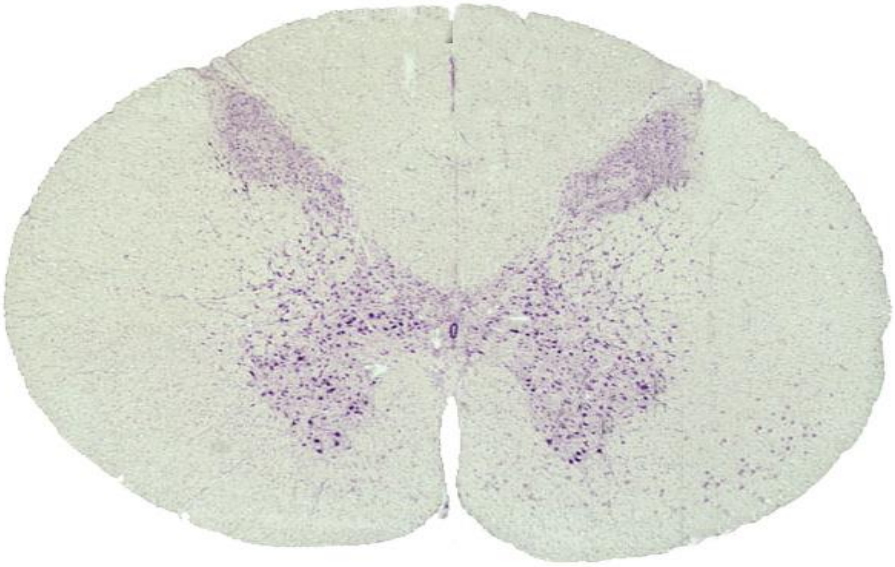
- Treat the tissue with a preservative (e.g. formaldehyde).
- Dissect the region of interest.
- Embed the tissue.
- Cut the tissue into thin sections.
- Stain the tissue to reveal subject of interest.
- Examine with a microscope.

Microscopy

- Different stains show different cell types, cell organelles or molecules.



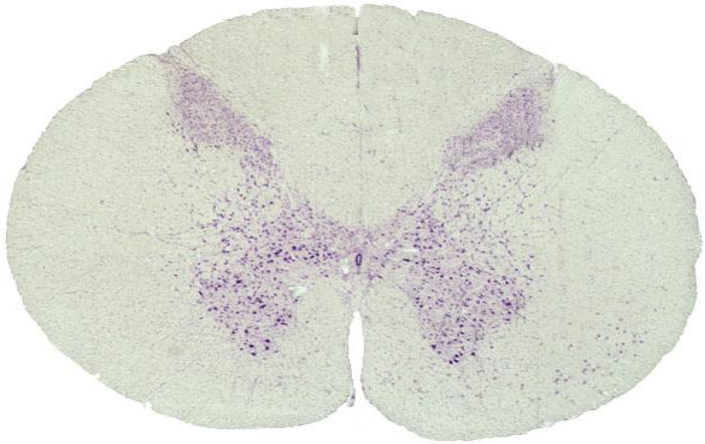
- This purple stain shows myelin, which is on axons.



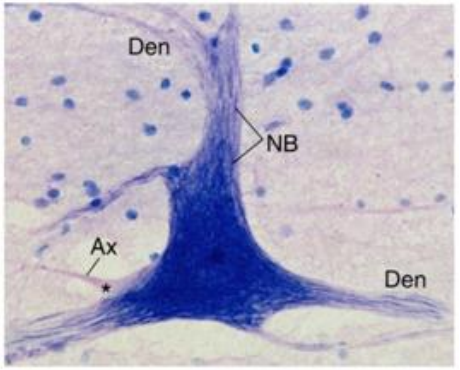
- This purple stain shows neuronal cell bodies.

Microscopy

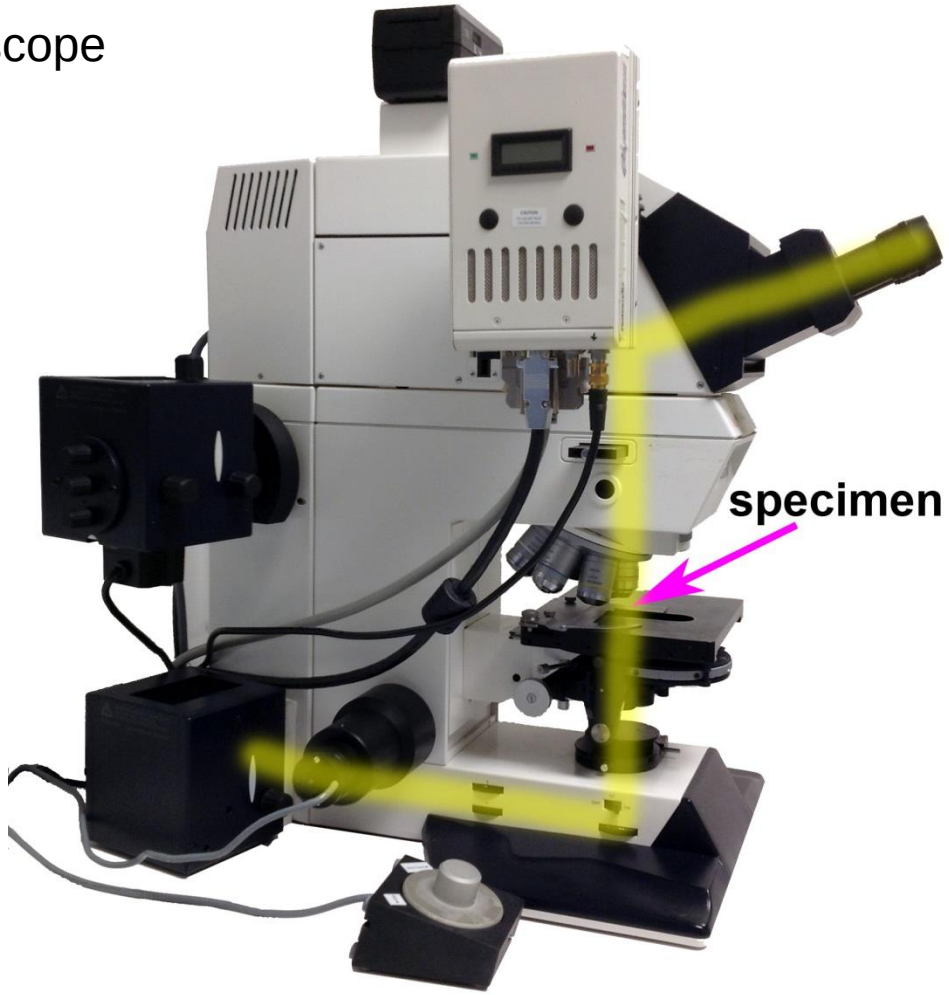
- (conventional) compound light microscope



low magnification

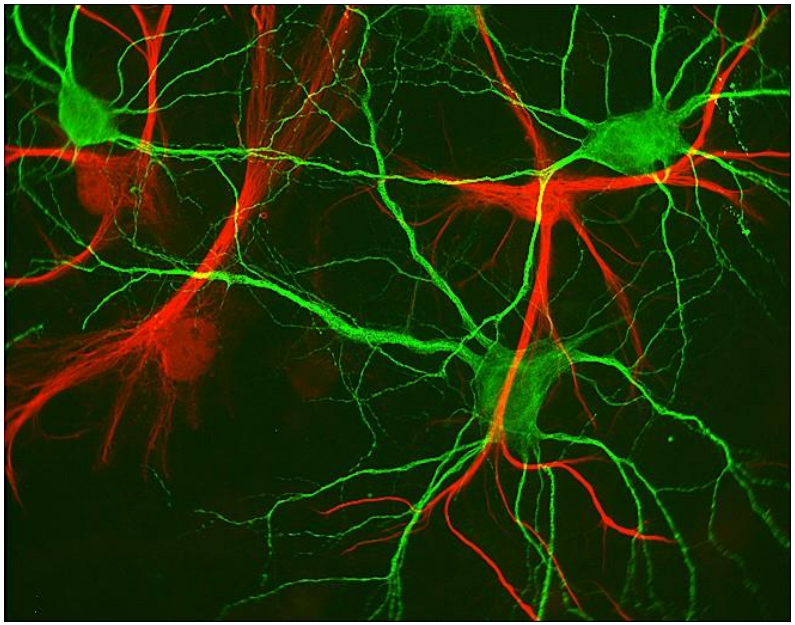


high magnification

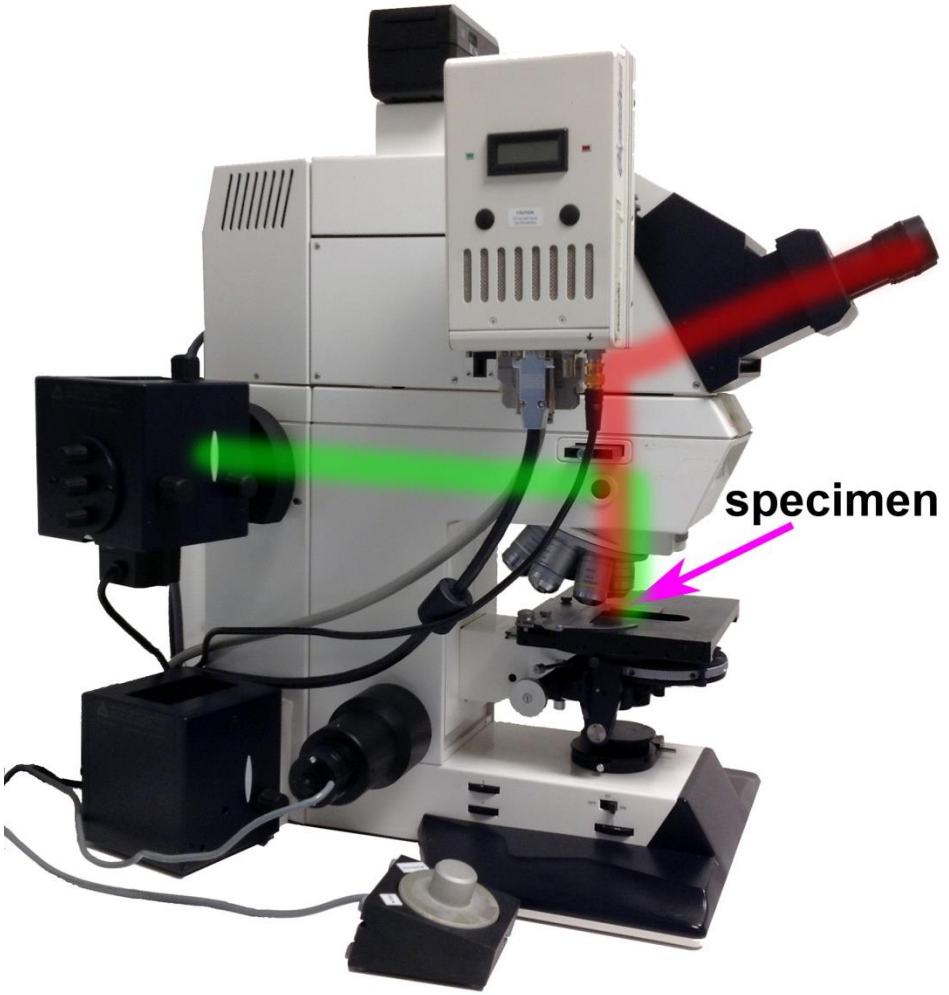


Microscopy

- fluorescence microscope

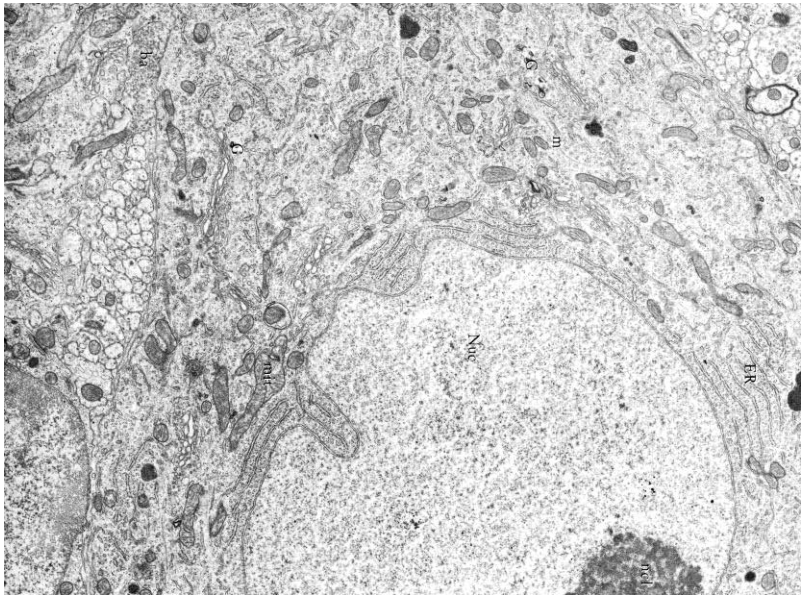


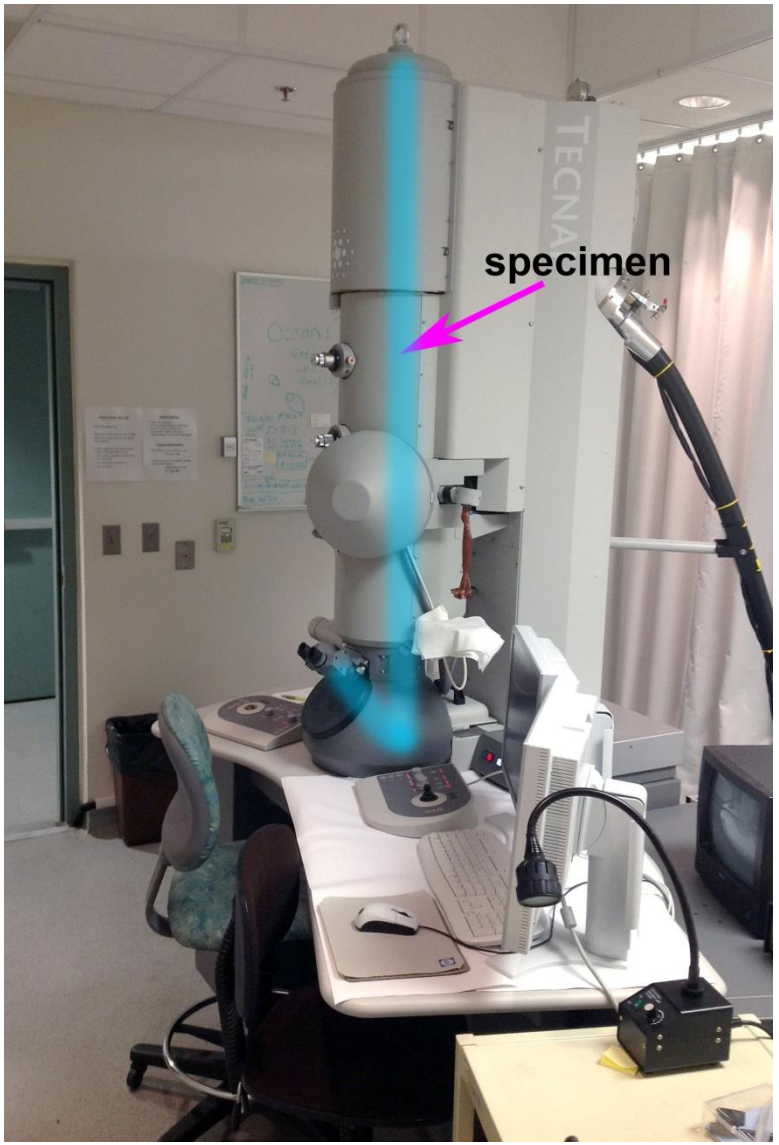
glial cell neuron



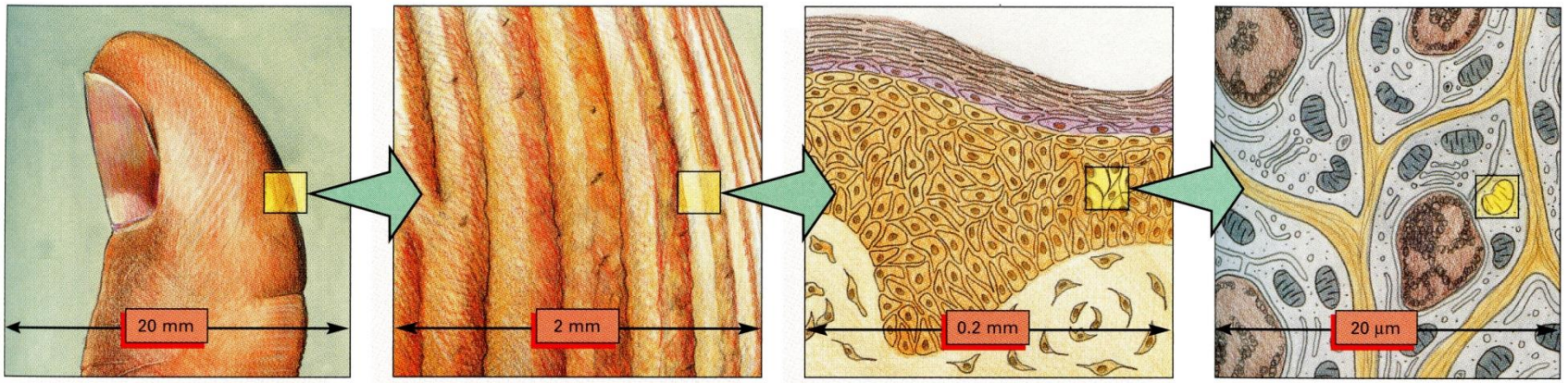
Microscopy

- electron microscope





Cells



- Cells are small – cell bodies (somas) of neurons range from 10 to 100µm in diameter

Cells

- A cell has organelles such as a nucleus and mitochondria
  (as a person has organs such as a brain and a liver)

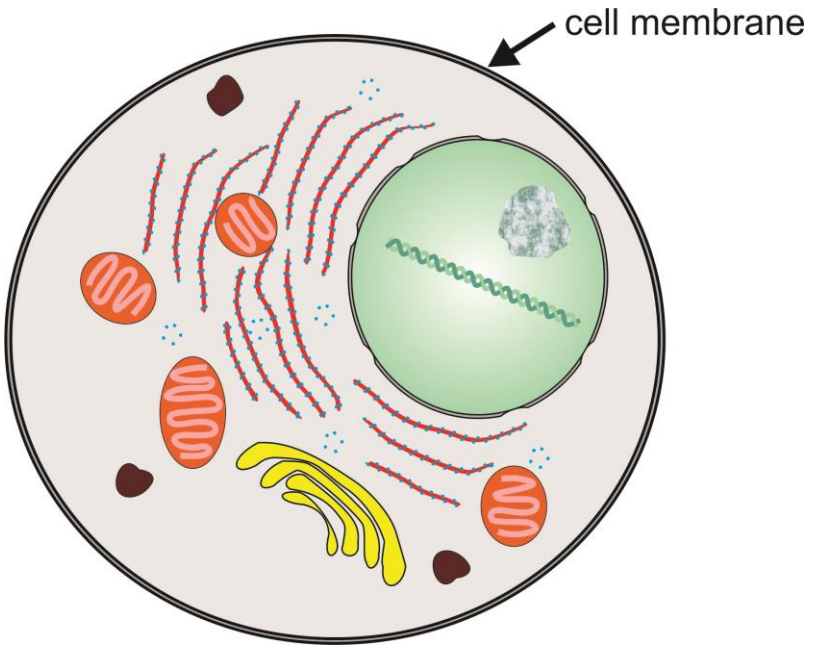
- The organelles of the cells of the nervous system are like those of most other cells of the body.

Organelles of Cells

Cell membrane (plasma membrane):

- Bounds the entire surface of the cell including the axon and dendrites of neurons.

- Its integrity is essential for normal cell function.

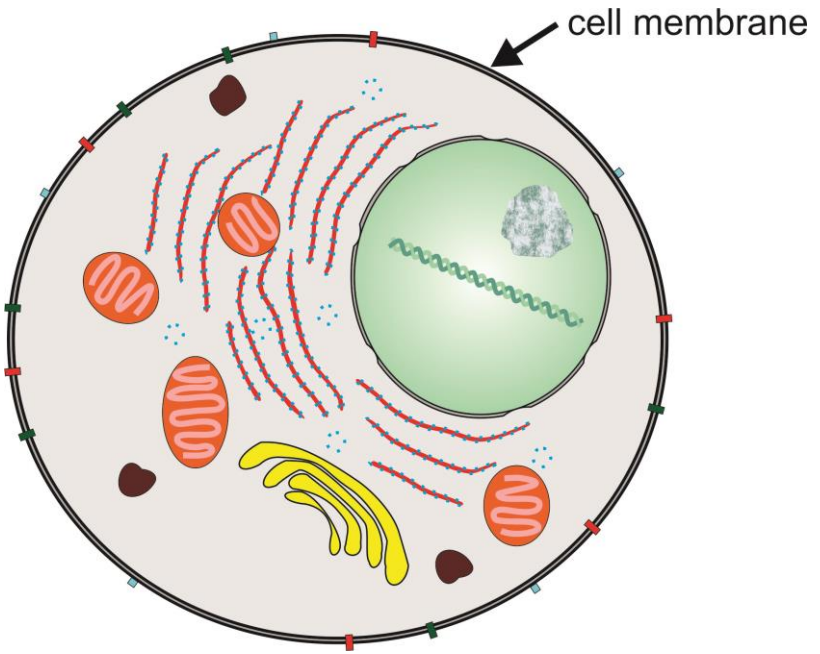


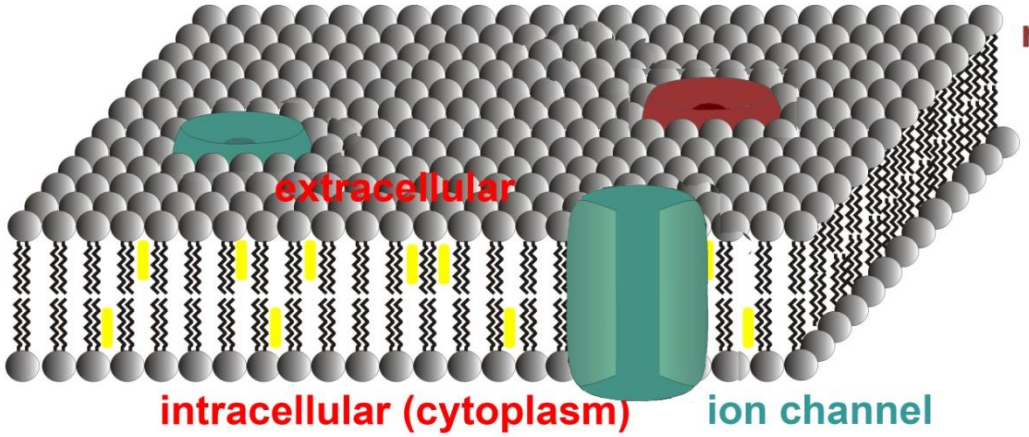
Organelles of Cells

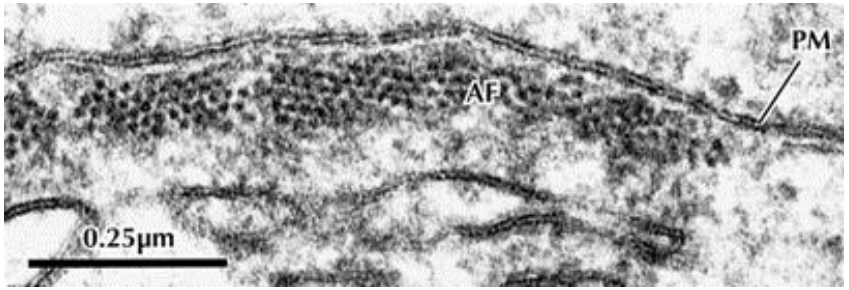
Cell membrane:

- Composed of a phospholipid bilayer, which forms an impermeable barrier to water and ions.

- Many proteins pass through or are attached to the membrane including:
  - Cell adhesion molecules
  - Ion channels & pumps
  - Receptors



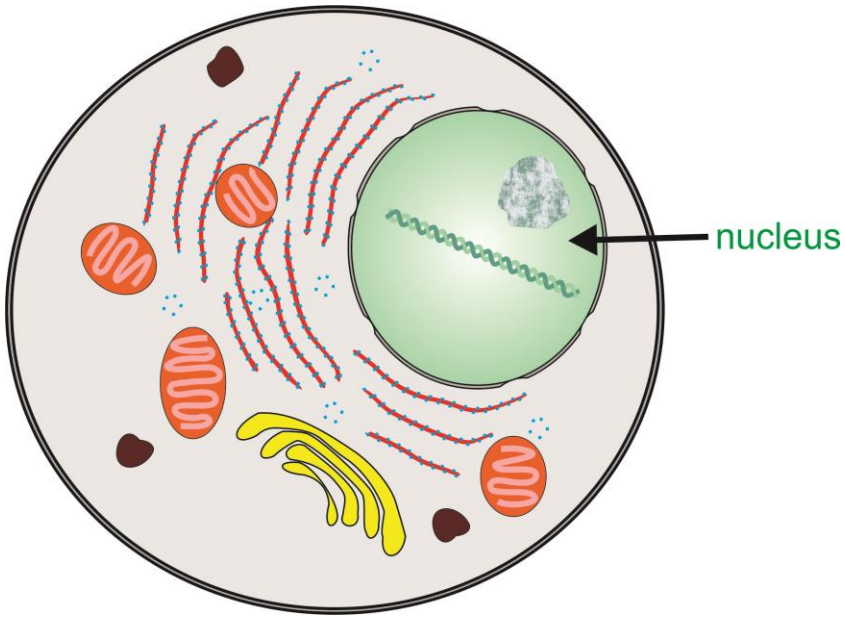




Organelles of Cells

Nucleus:

- The most conspicuous organelle of a cell.



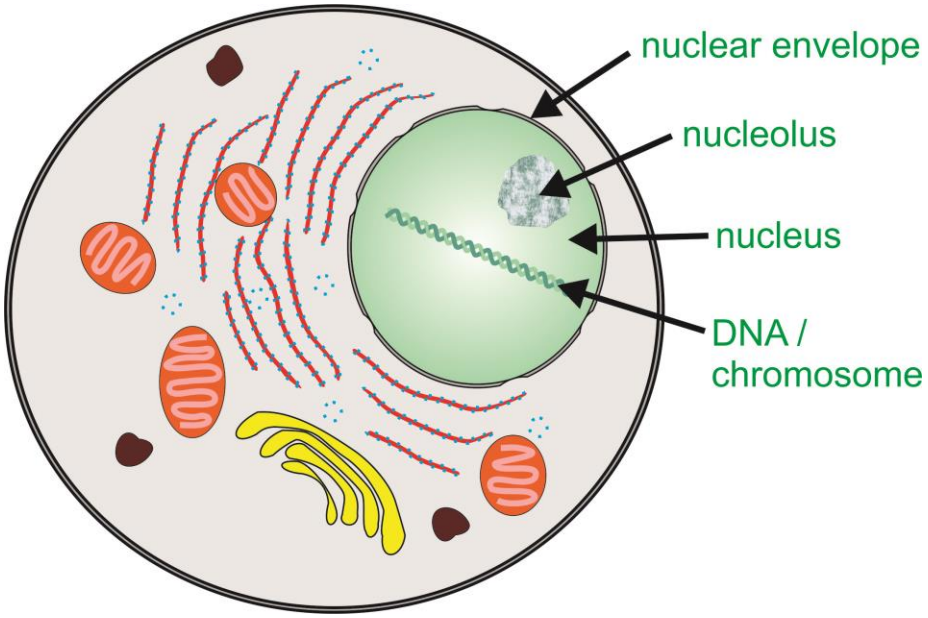
Organelles of Cells

Nucleus includes:

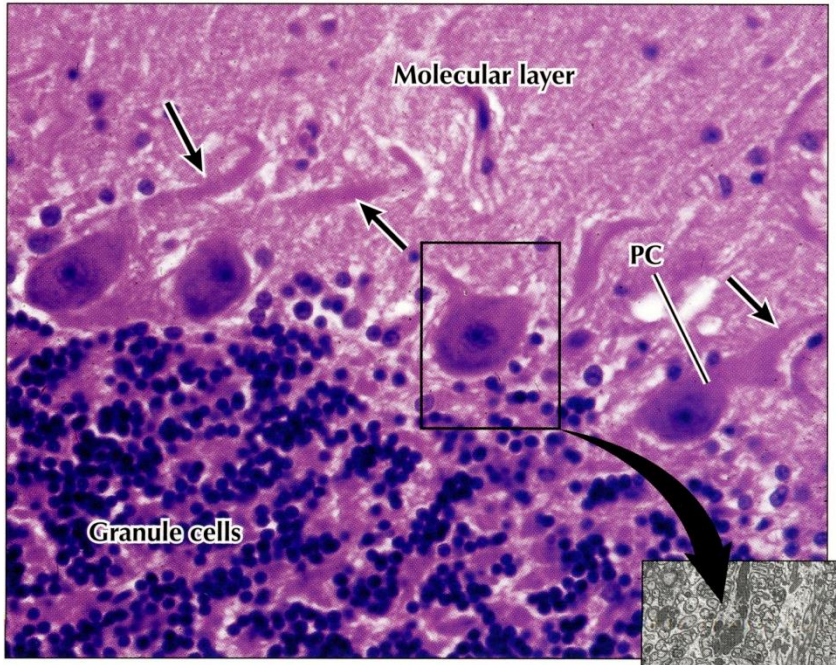
- Nuclear envelope with pores, which surrounds the nucleus and allows selected molecules to pass between the nucleus and cytoplasm

- Nucleolus, which has important roles in genesis of ribosomes

- Chromosomes, which are double strands of DNA complexed with proteins

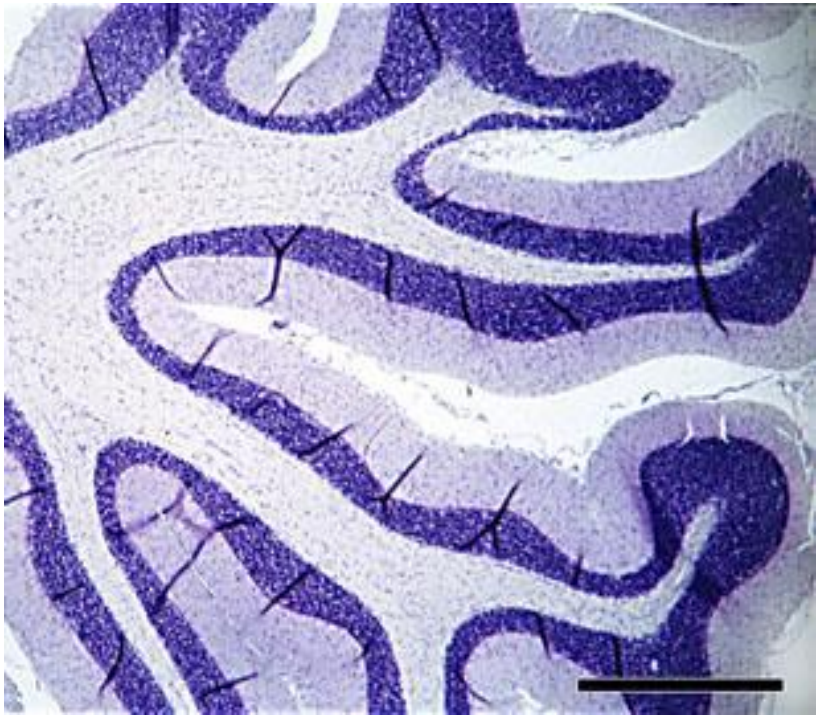


Nucleus:

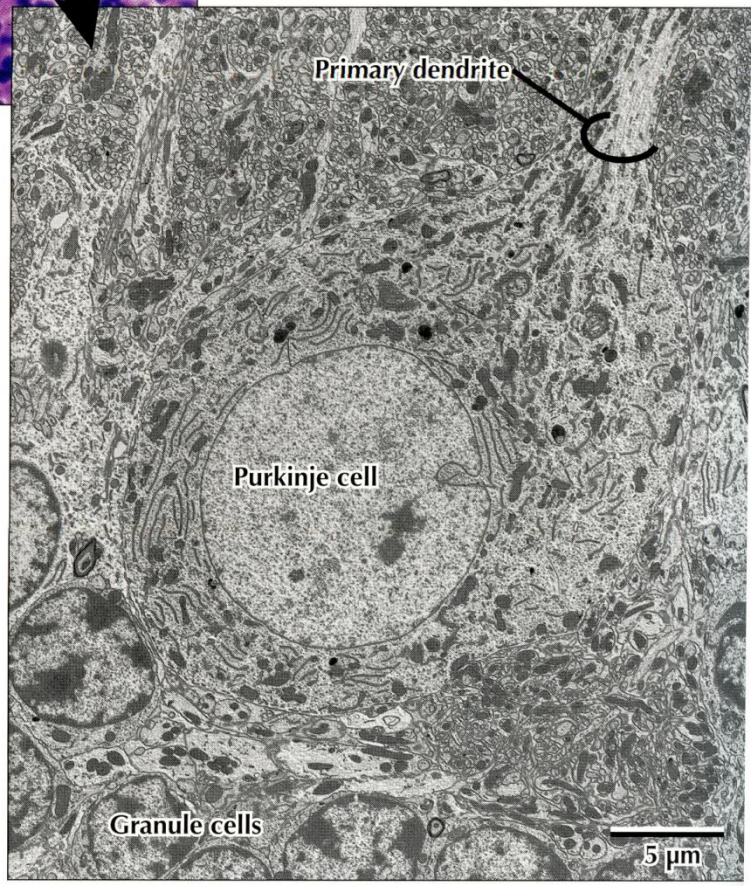


Medium magnification light micrograph

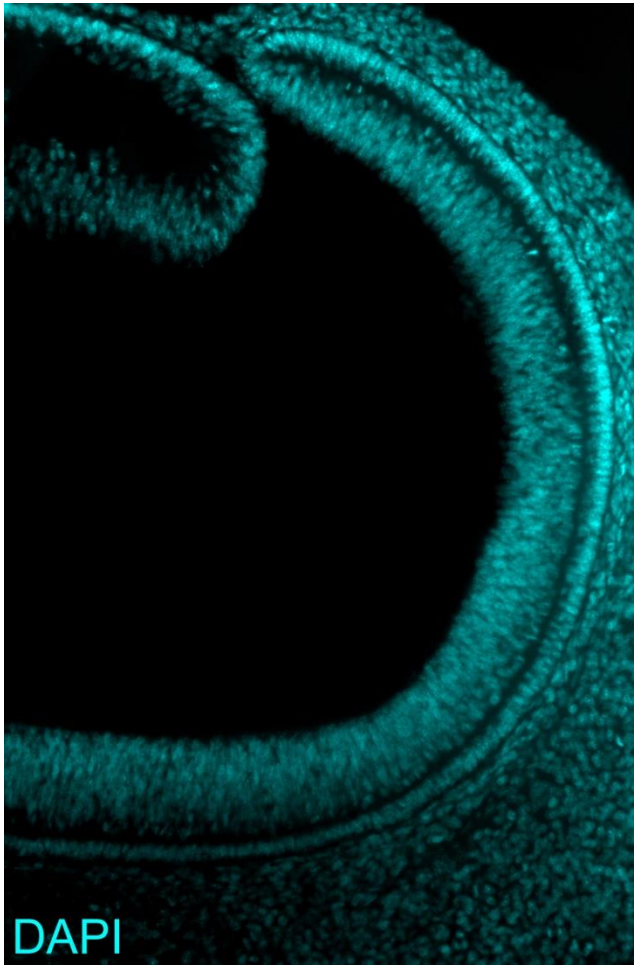
Low magnification light micrograph



Electron micrograph



Nucleus:



Low magnification fluorescence micrograph

Genes & Protein Synthesis

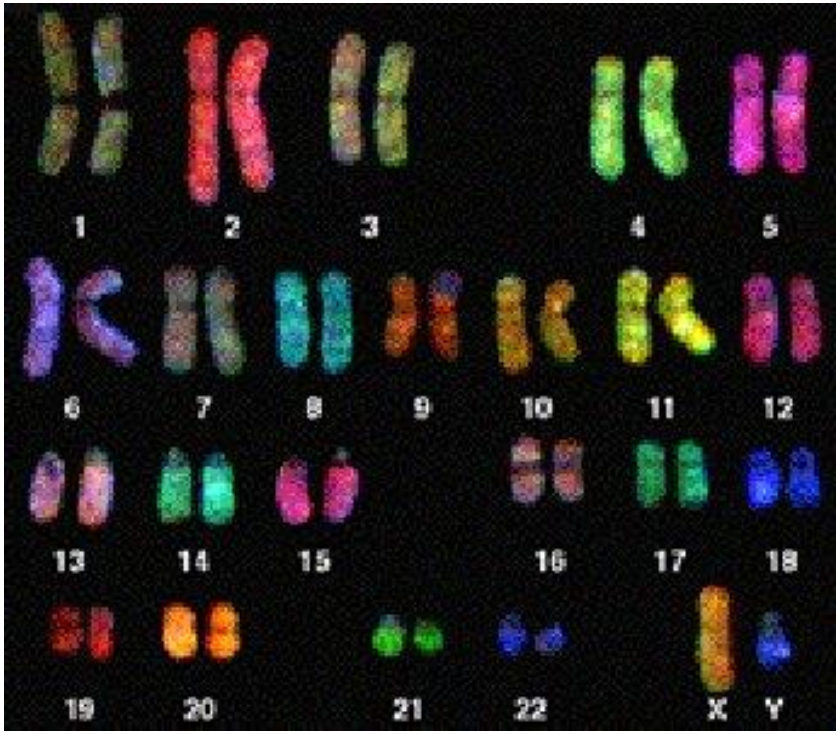
Chromosomes:

- Humans normally have 23 pairs of chromosomes, the last of which are the sex chromosomes.

- Females are XX, and males are XY.

- Deletion or duplication of a chromosome can cause abnormalities.

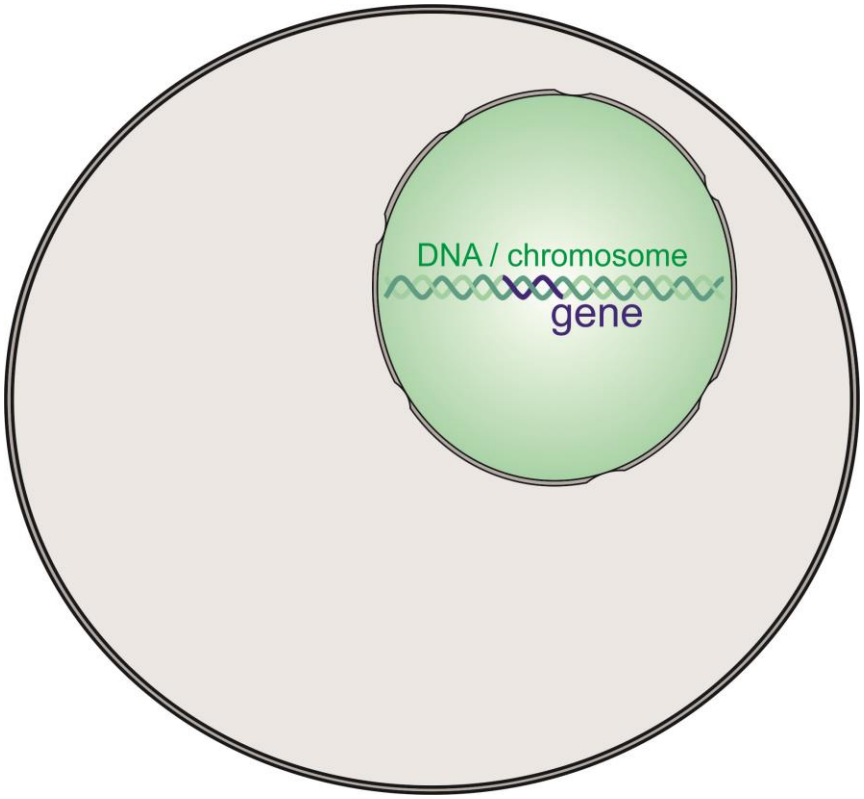
  A third copy of chromosome 21 results in Down's syndrome, a common cause of mental retardation.



Genes & Protein Synthesis

DNA & Genes

- DNA is a helical chain of four types of nucleotides in a specific sequence.
- Many segments of the DNA of a chromosome are genes. A gene encodes the instructions for synthesis of a protein.
- Humans have ~23,000 genes.
- Genes are the basis of heredity.
- Most cells of an individual have the same DNA (genes).



Genes & Protein Synthesis

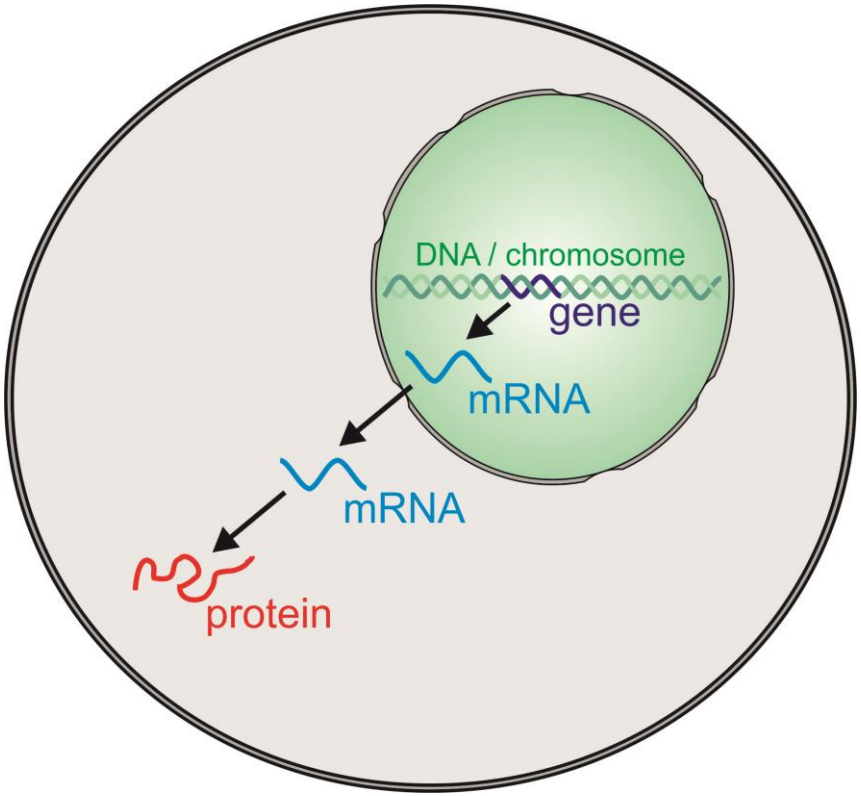
Protein synthesis:

- A gene is used as a template for synthesis of messenger RNA (mRNA) in the nucleus

- mRNA is used as a template for synthesis of a protein in the cytoplasm.

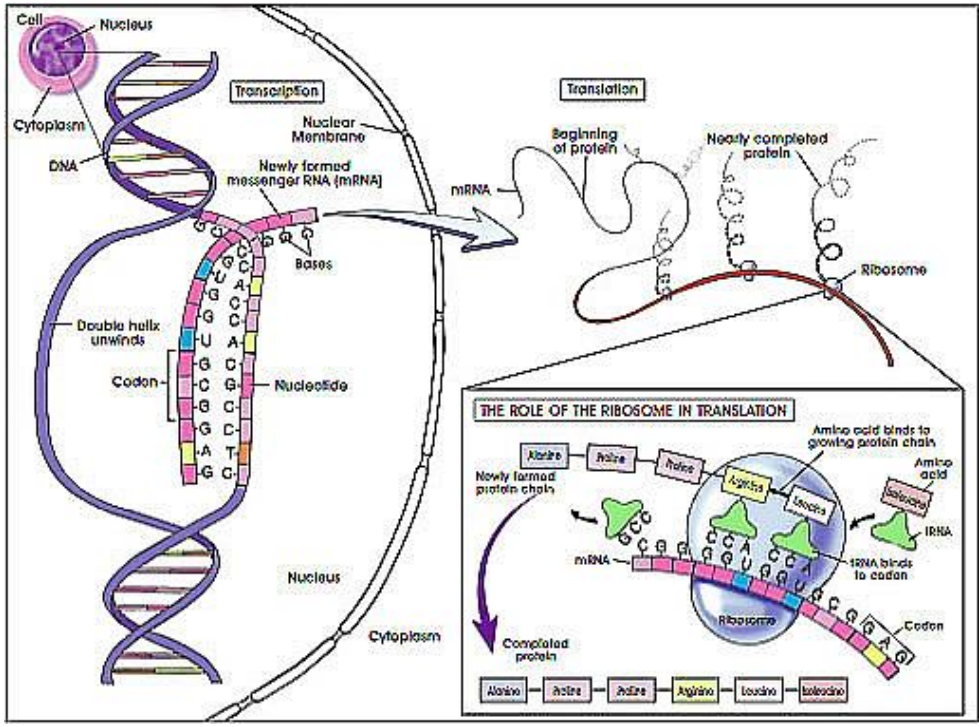
  DNA (gene) > mRNA > protein

- Different cell types express only certain proteins. The function of a cell is determined by the proteins it expresses.



Genes & Protein Synthesis

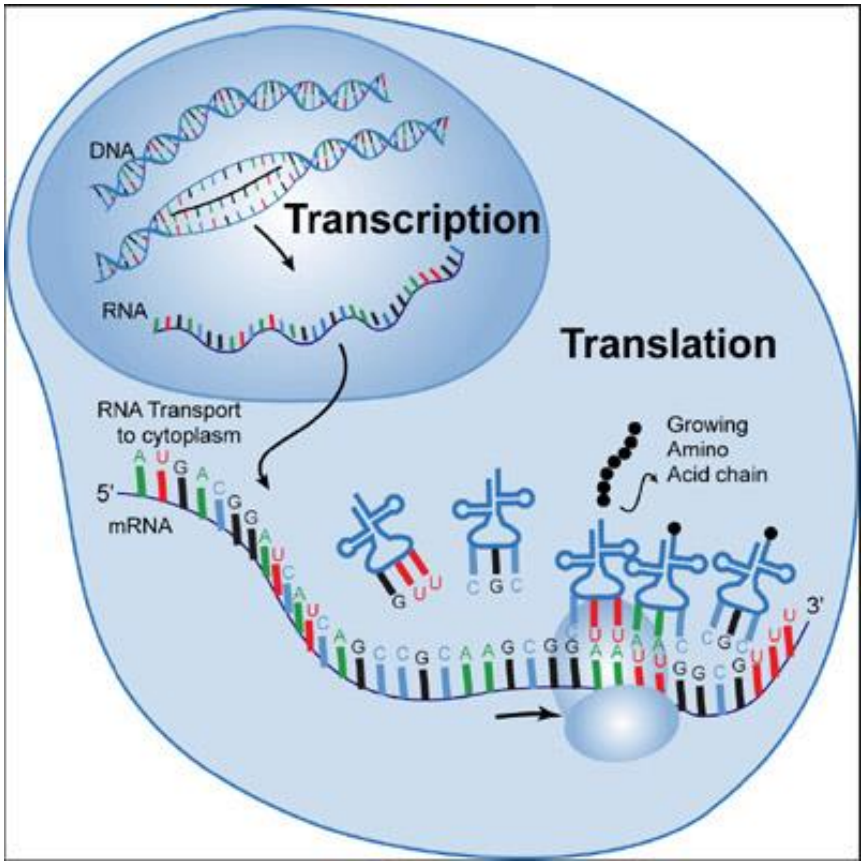
- DNA is a chain of four nucleotides.
- mRNA is a chain of four slightly different nucleotides.
- Protein is a chain of amino acids.
- The sequence of three nucleotides in the mRNA specifies the amino acid to assemble into the protein being synthesized.
- Thus, the sequence of nucleotides in a gene (DNA) ultimately determines the sequence of amino acids in a protein.



Genes & Protein Synthesis

- Synthesis of mRNA from DNA in the nucleus is a process called transcription.

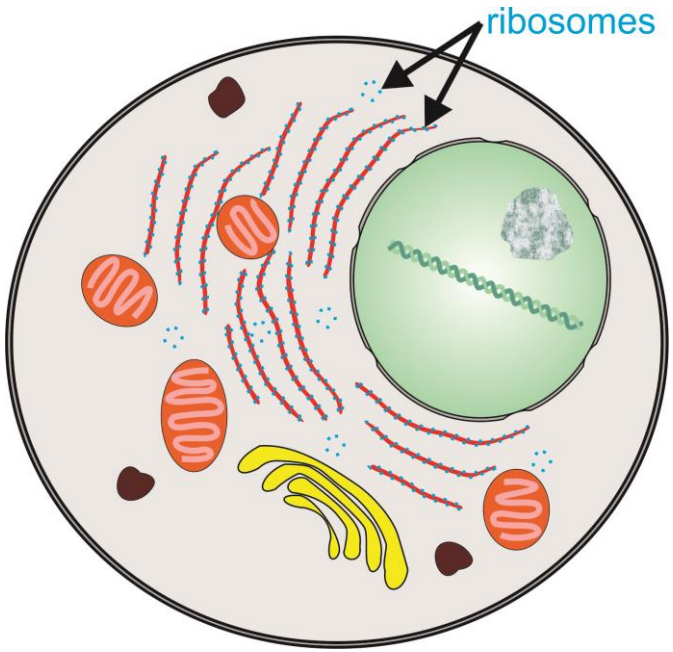
- Synthesis of protein from mRNA in the cytoplasm is a process called translation.



Organelles of Cells

Ribosome:

- Reads the sequence of mRNA to synthesize proteins.

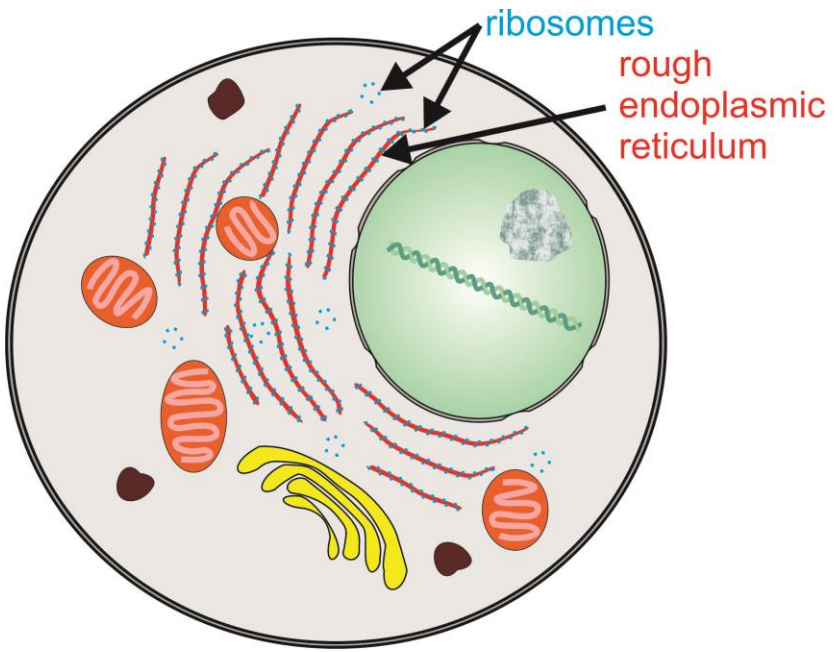


Organelles of Cells

Endoplasmic reticulum:

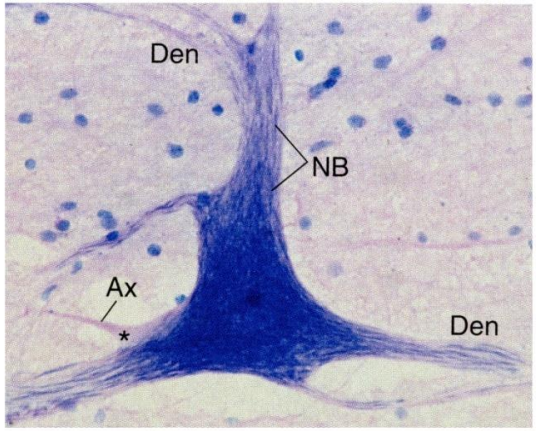
- Interconnected network of tubules in the cytoplasm

- Rough endoplasmic reticulum have ribosomes on its surface and is important for synthesis of membrane proteins and proteins for export.



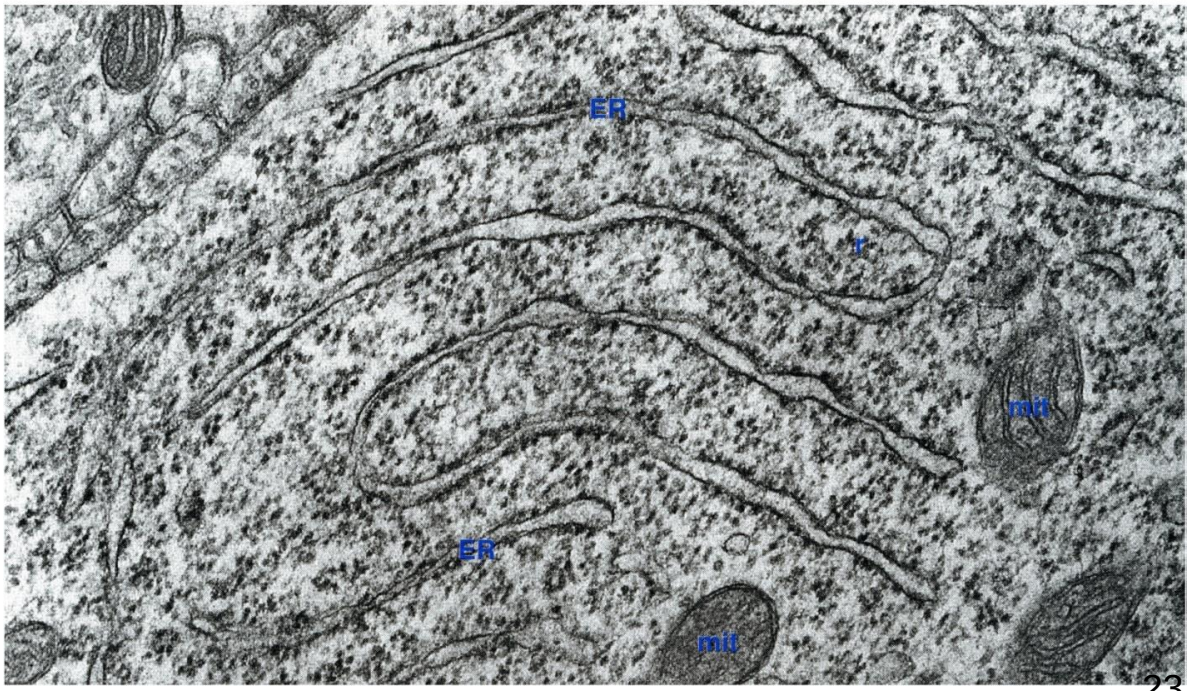
Organelles of Cells

- Neurons have large amounts of rough endoplasmic reticulum in their somas, which we call Nissl substance.



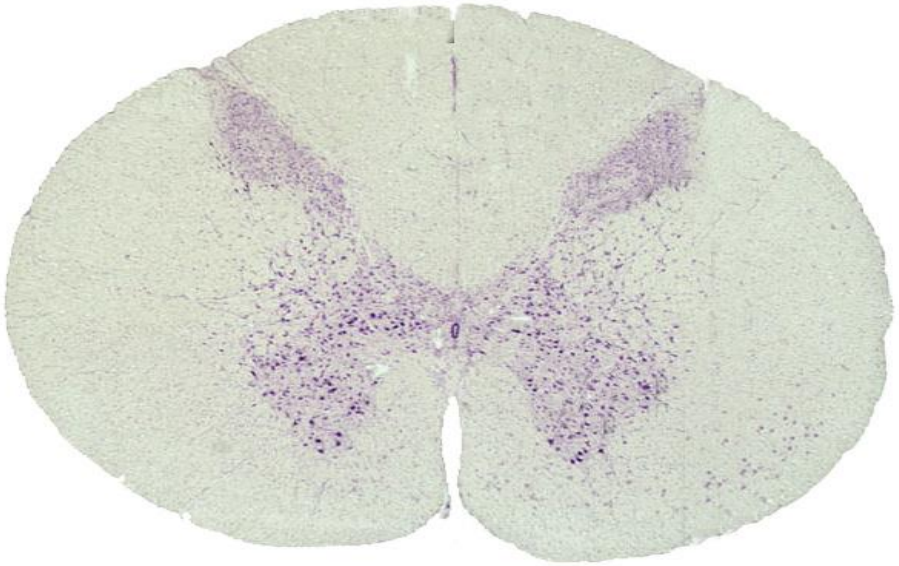
- Nissl substance is readily seen by microscopy.

- Most proteins and other molecules needed by neurons are synthesized in the soma.

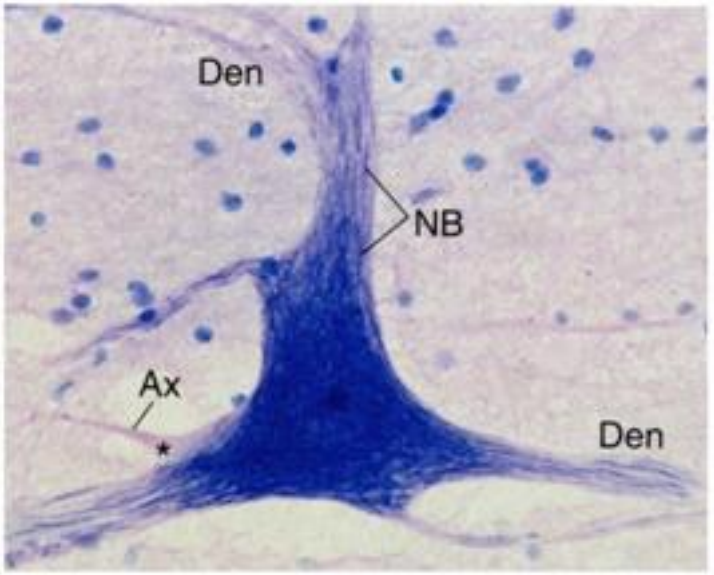


Organelles of Cells

Nissl stain:



Low magnification light micrograph of spinal cord

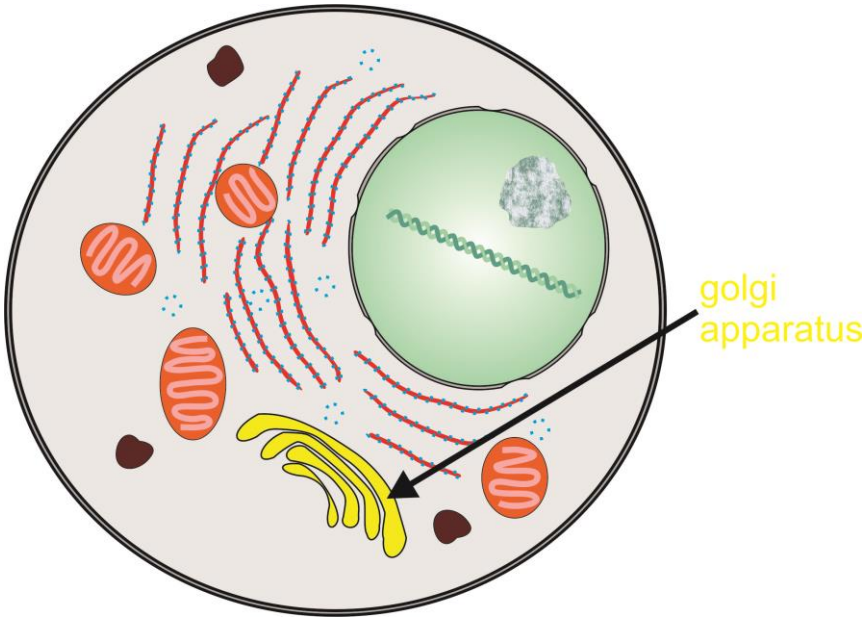


High magnification light micrograph of a spinal neuron

Organelles of Cells

Golgi apparatus:

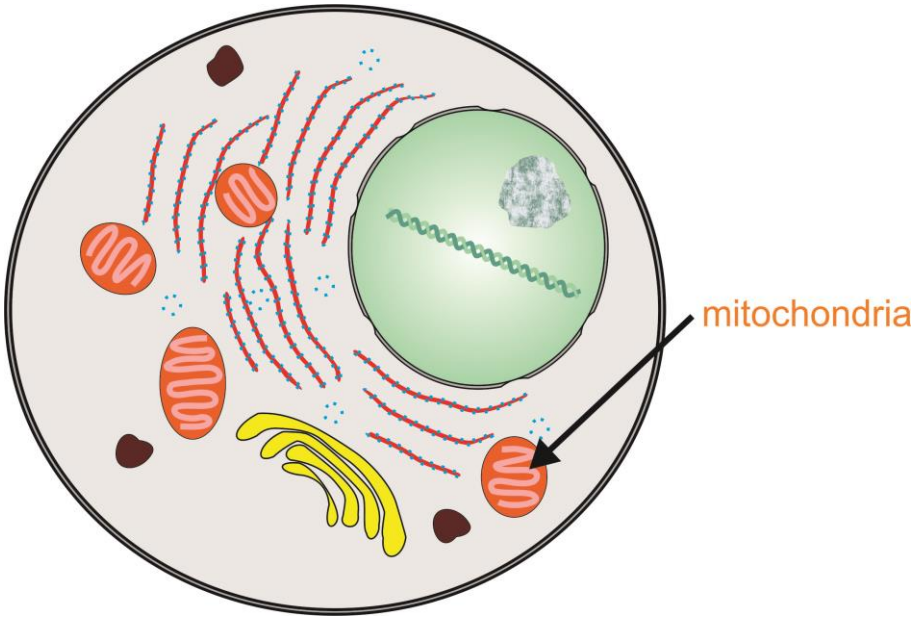
- Flattened membrane bound sacs
- Modifies newly synthesized proteins and lipids
- Gives rise to vesicles for transport throughout the cell



Organelles of Cells

Mitochondria:

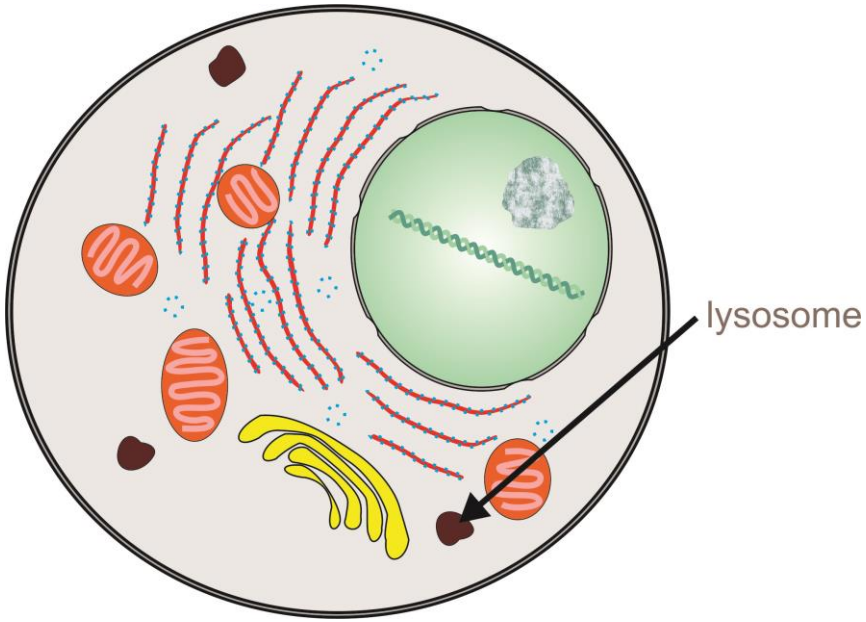
- Supply energy in a form that can be used by most enzymes in the cell



Organelles of Cells

Lysosome:

- Breaks down organelles and molecules for recycling.



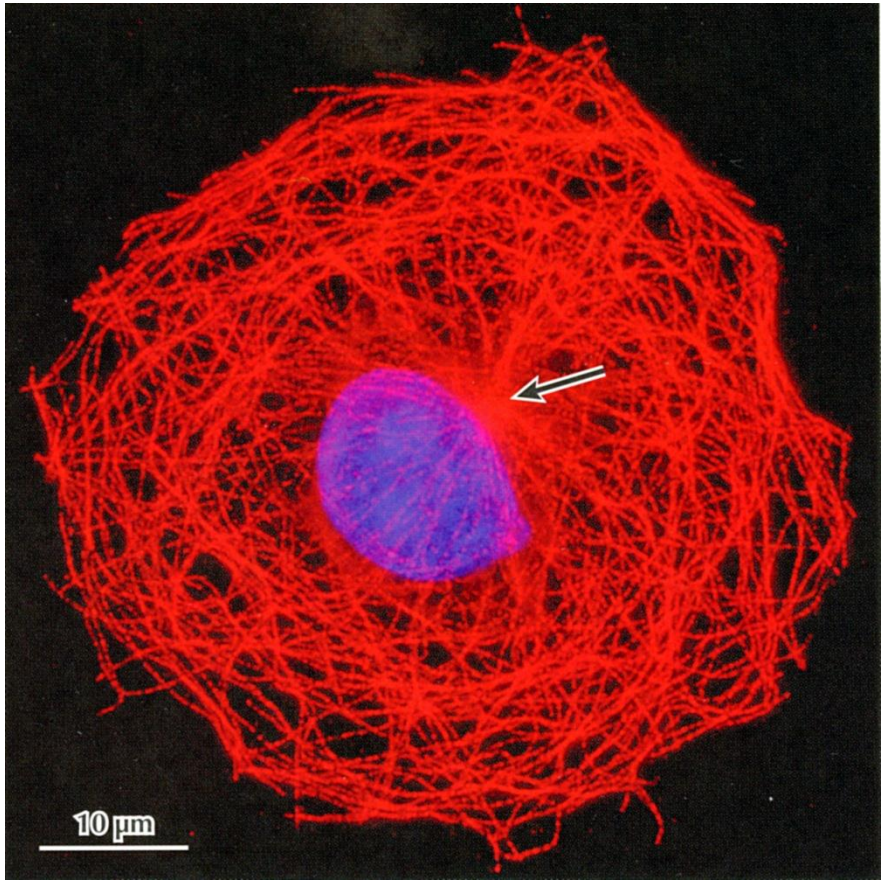
Organelles of Cells

Cytoskeleton:

- Filaments of structural proteins present in a matrix throughout the cell.

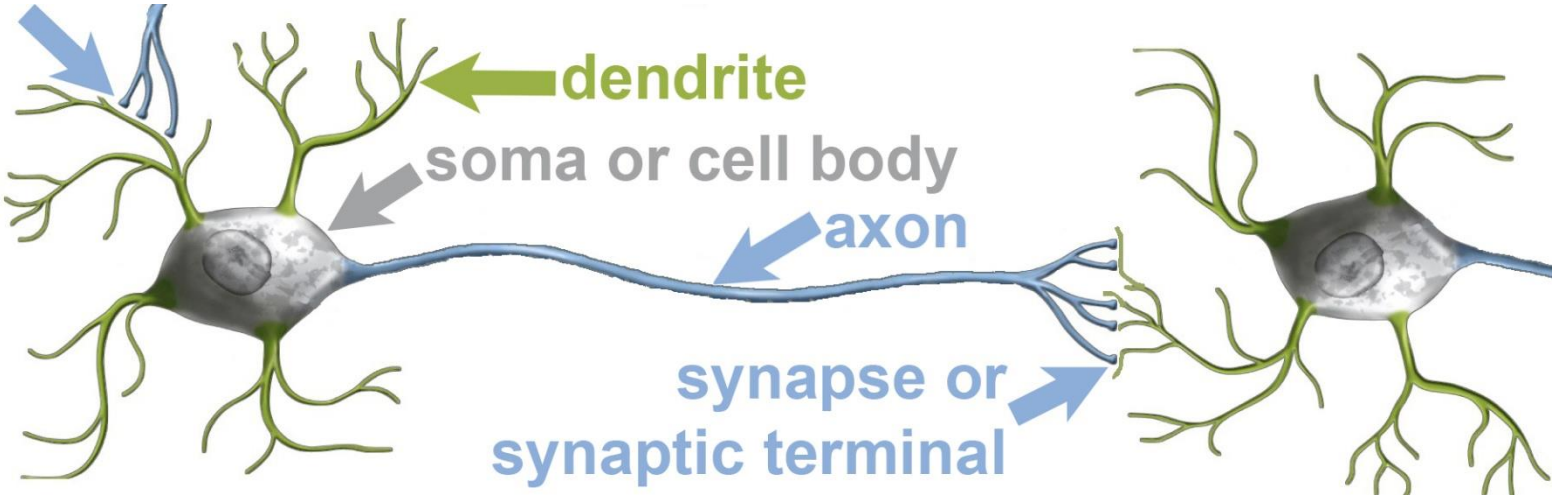
- Maintains the shape of the cell, involved in the transport of molecules and organelles, and involved in cell movement.

- Three main elements:
  - Microtubules (tubulin)
  - Intermediate filaments (neurofilament protein in neurons)
  - Microfilaments (actin)



microtubules
nucleus

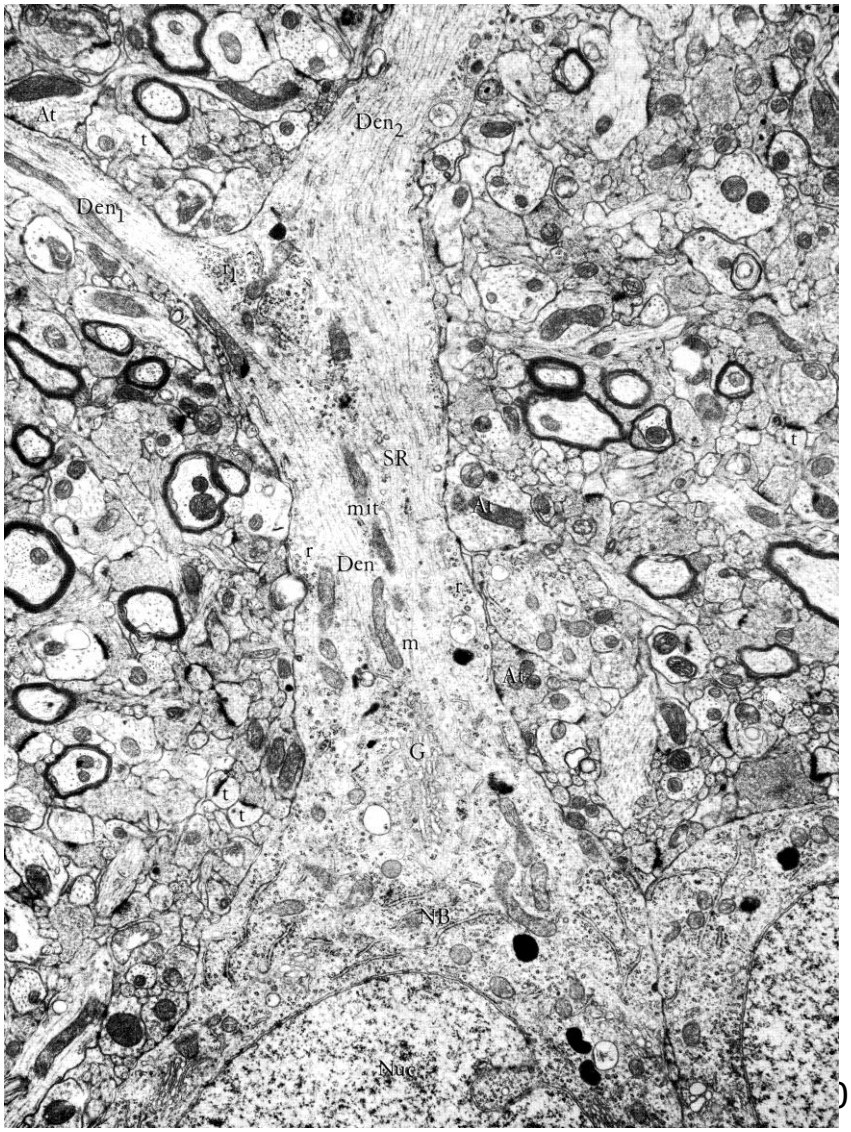
Main Parts of a Generic Neuron



- dendrite
- soma
- axon
- synapse

Axonal Transport

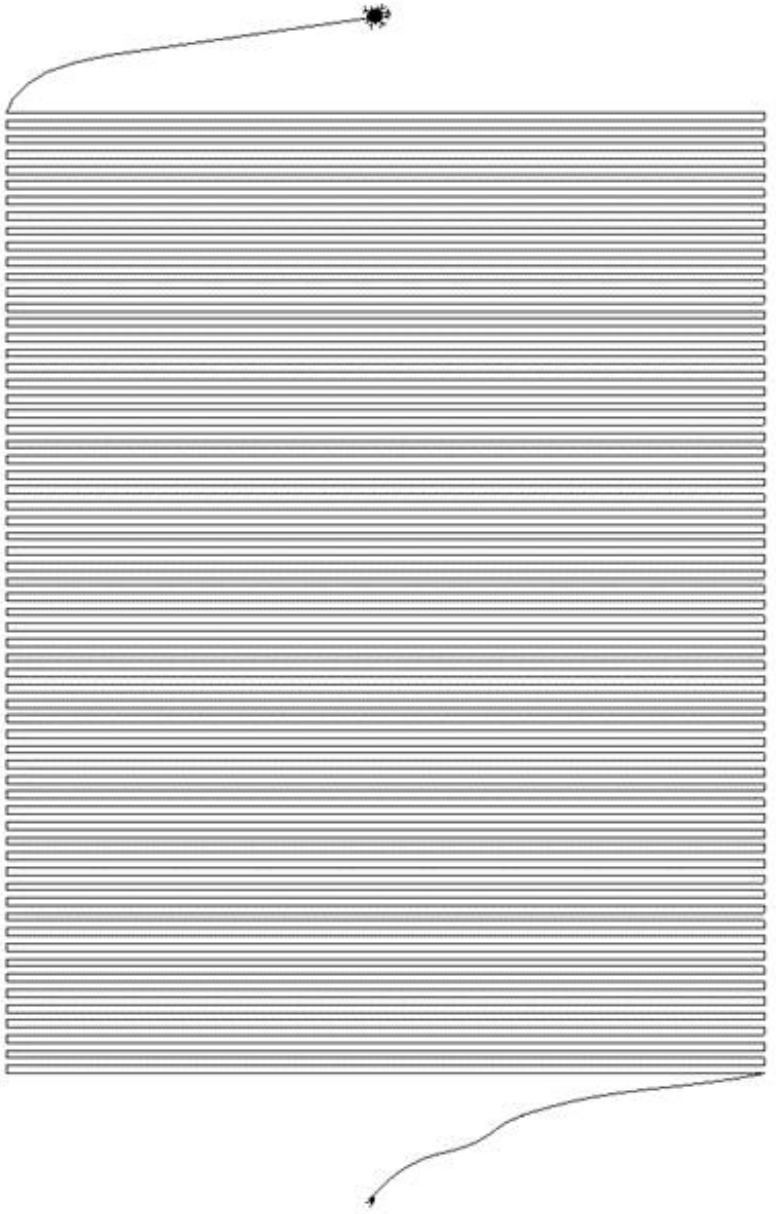
- In neurons, most protein synthesis takes place in the cell body.
- Very little mRNA is present in the axon.



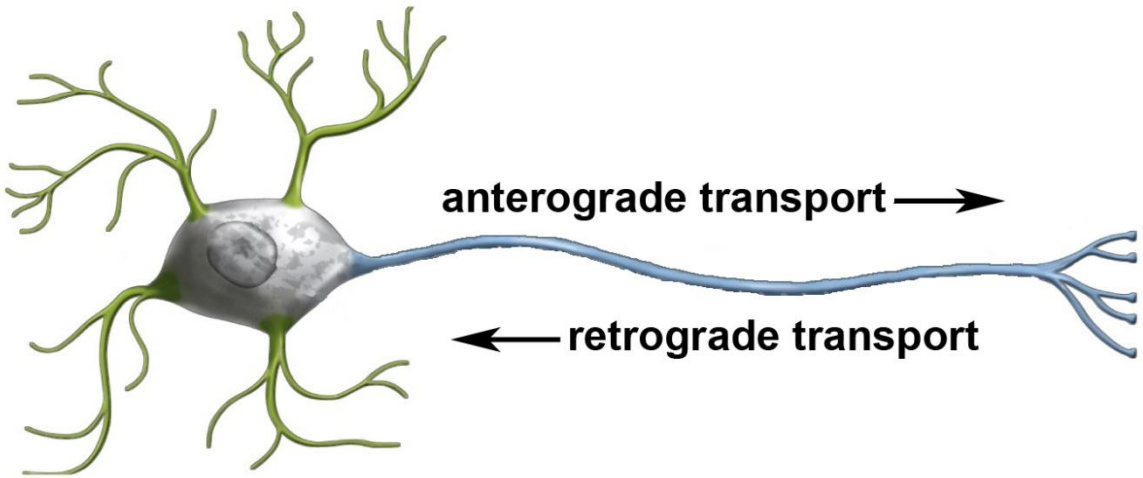
Axonal Transport

- Yet most of the volume of a neuron can be in its axon.

- Axonal transport is required to move molecules and organelles around the cell.



Axonal Transport

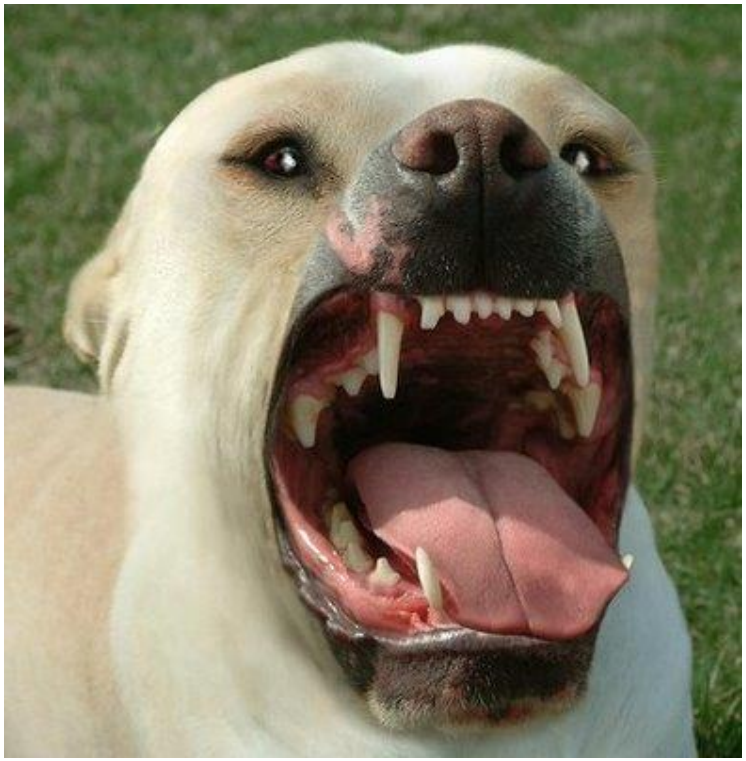


- Different components of the cytoskeleton are involved in transport within the axon to and from the soma.

Axonal Transport

Rabies:

- Rabies is a virus usually introduced through the skin via an animal bite.
- The virus is taken up by peripheral nerves and taken by axonal transport into the central nervous system where it has its primary effect.
- When the virus reaches the soma of a neuron, it releases its mRNA, which leads to synthesis of viral proteins.
- The viral proteins damage the host neuron and lead to production and release of more viruses.



Axonal Transport

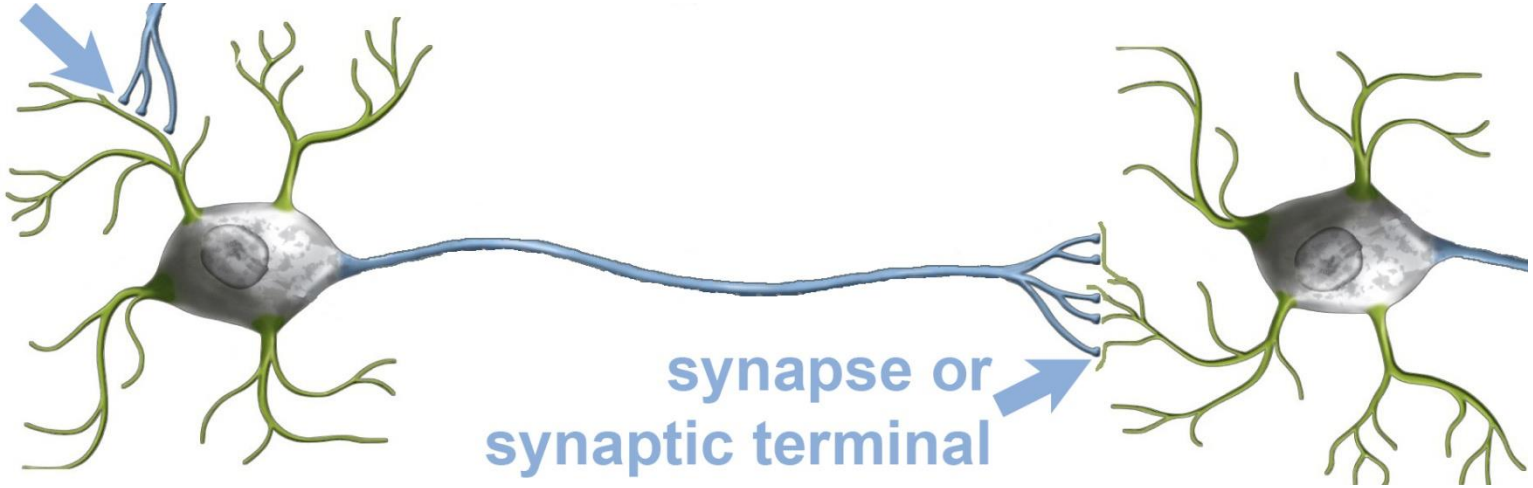
Herpes simplex:

- A virus responsible for genital herpes, a sexually transmitted disease (STD).

- It is transmitted between partners during unprotected sex.

- It is transported in sensory axons, and will survive in the soma of sensory neurons for life.

Synapse

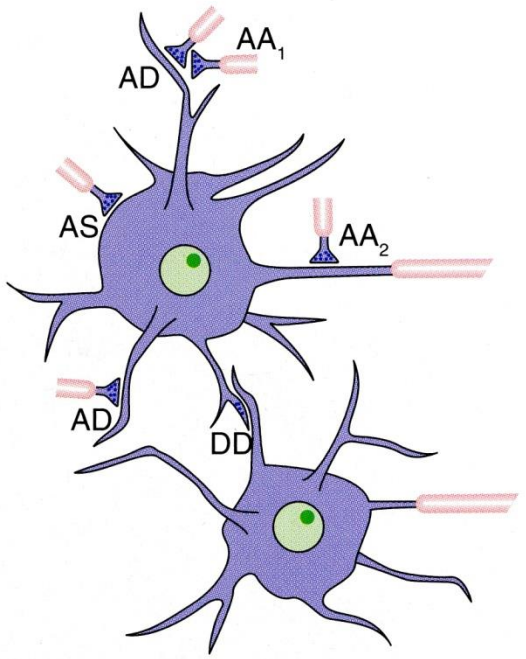


Synapse or synaptic terminal

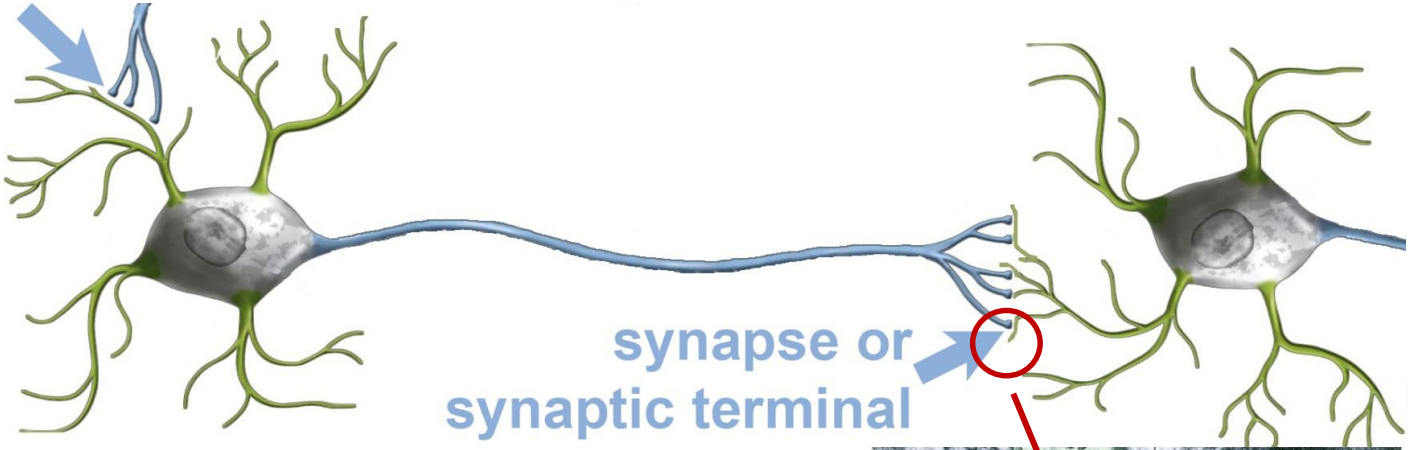
- Termination of an axon
- Site of communication with another cell
  (The presynaptic cell communicates with the postsynaptic cell.)
- Postsynaptic cell can be another neuron or other cell type.

Synapse

- Synapses between neurons can be:
  - axodendritic
  - axosomatic
  - axoaxonic
  - dendrodendritic

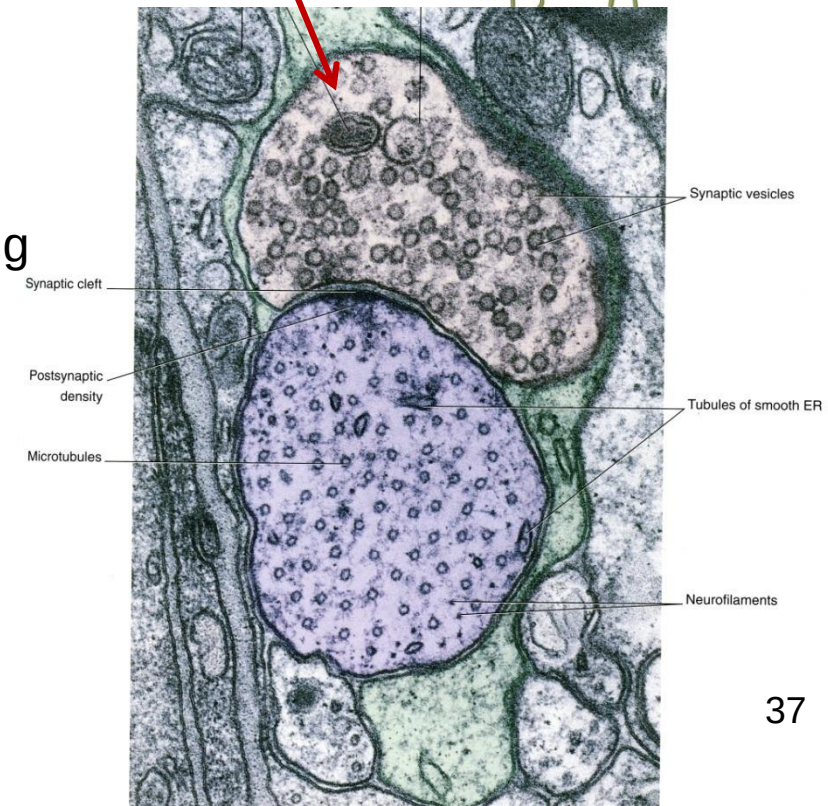


Synapse

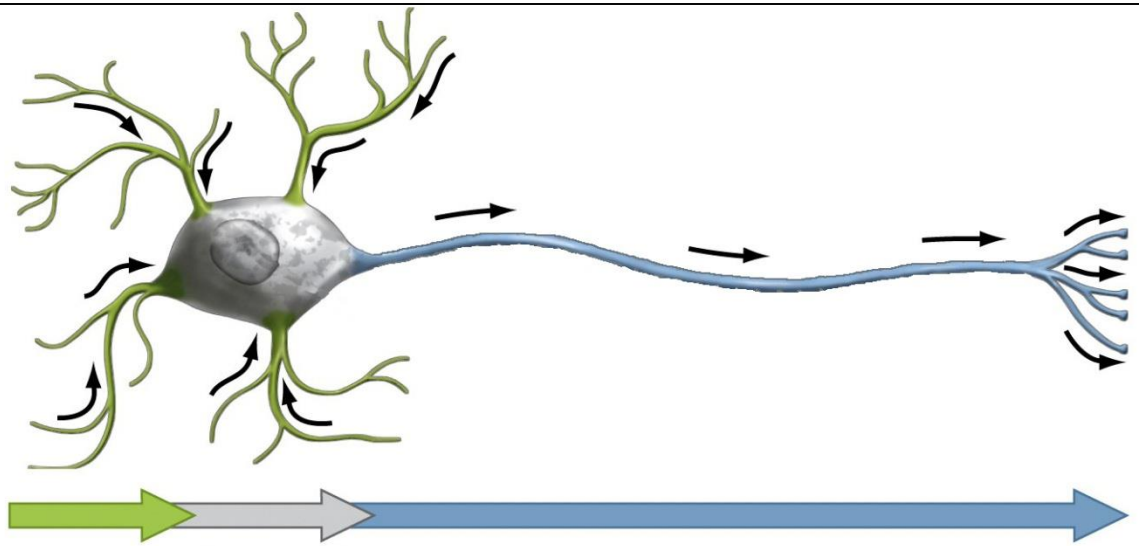


Structure of a typical synapse:

- Presynaptic terminal
    - Synaptic vesicles containing neurotransmitter
    - Presynaptic density
- Synaptic cleft
- Postsynaptic element
    - Neurotransmitter receptors
    - Postsynaptic density



Synapse



Action Potential

- When the neuron is activated, an electrical pulse, the action potential, is carried down the axon.

Synaptic Communication

- When an action potential reaches a synapse, synaptic vesicles fuse with the cell membrane and release neurotransmitter into the synaptic cleft.
- Neurotransmitter crosses the synaptic cleft and interacts with receptors on the postsynaptic cell.
- Neurotransmitter will activate or inhibit the postsynaptic cell.

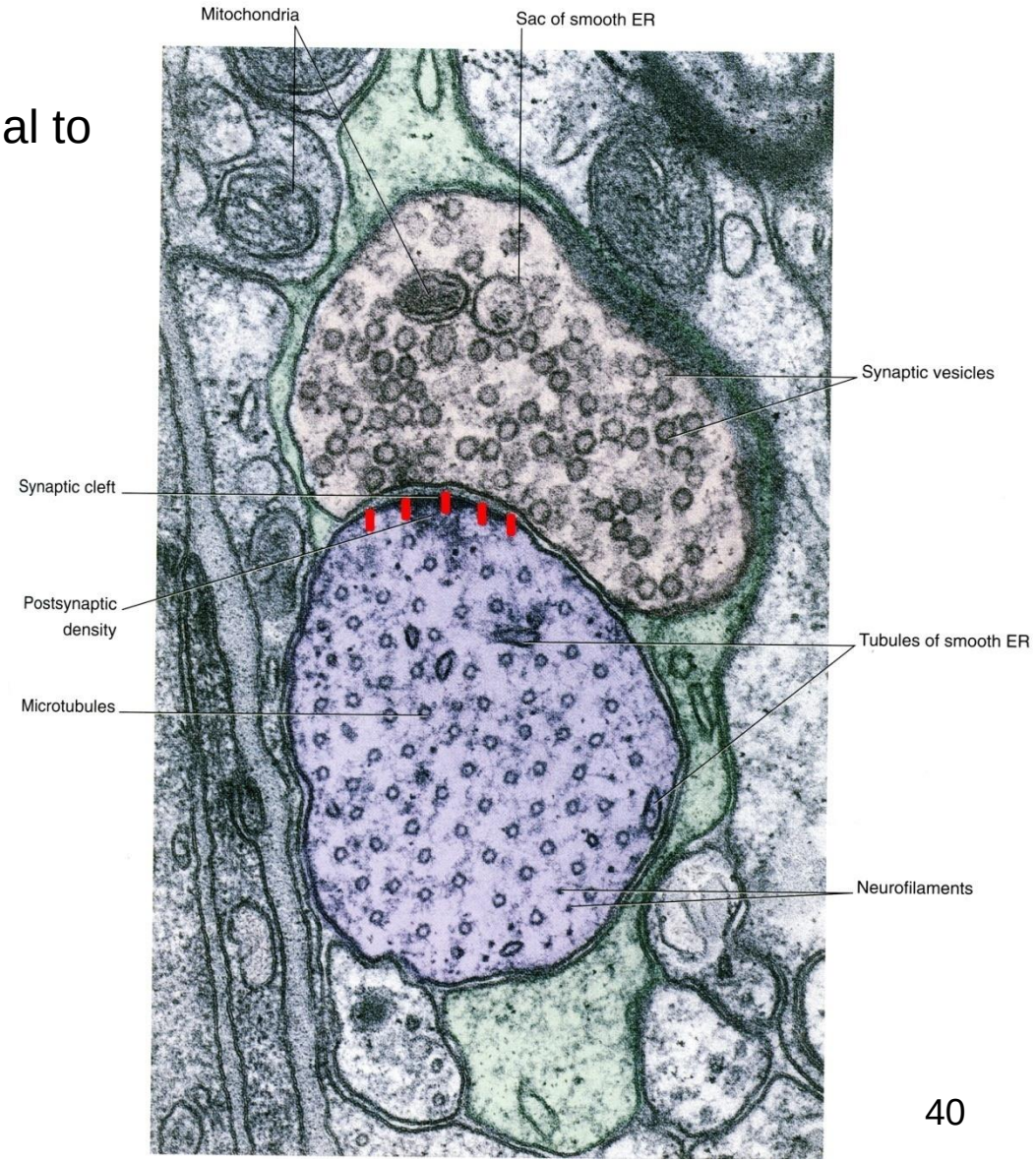
Synapse

- Different types of neurons release different neurotransmitters.
- Some common neurotransmitters:

class	***transmitter***
biogenic amines	acetylcholine
	dopamine
	norepinephrine (noradrenaline)
	epinephrine (adrenaline)
	serotonin
amino acids	γ-aminobutyric acid (GABA)
	glutamate
	glycine
peptides	vasoactive intestinal polypeptide
	substance P
	enkephalin
	endorphin

Synapse

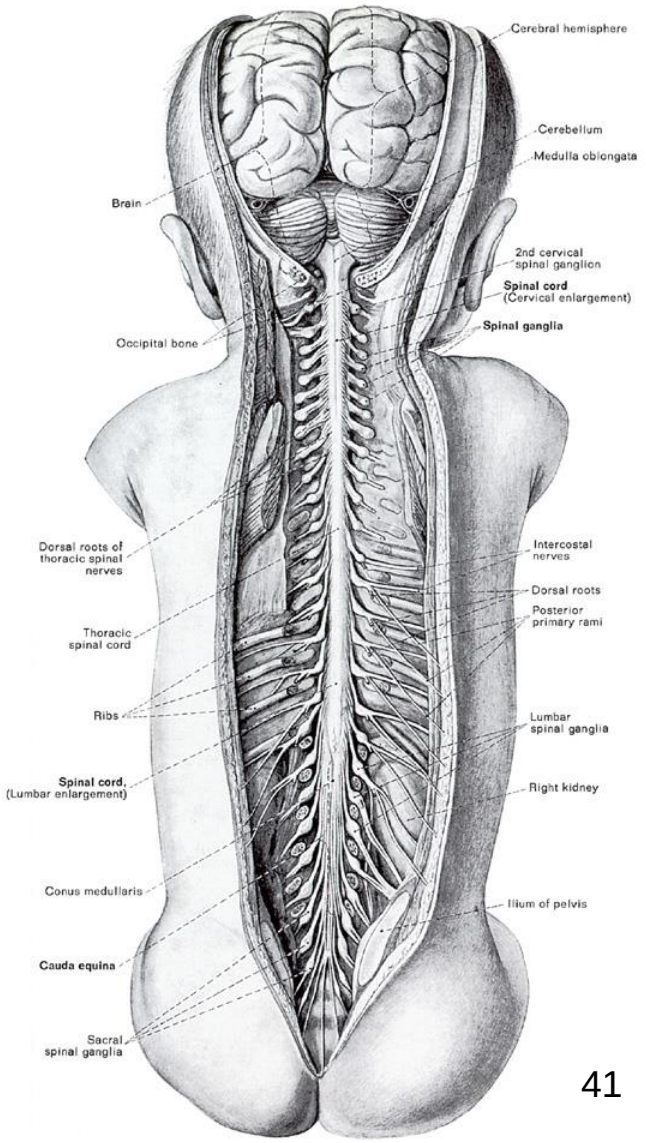
- Neurochemical communication requires the postsynaptic terminal to have the proper receptor for the neurotransmitter.
- The transmitter-receptor pair determines whether the active synapse will excite or inhibit the postsynaptic cell.



Glia (Neuroglia)

(The Non-neuronal Cells of the Nervous System)

- Central nervous system (CNS) includes the brain, spinal cord and retina.
- Peripheral nervous system (PNS) includes nerves and ganglia, which are distributed throughout the body.



Glia (Neuroglia)

(The Non-neuronal Cells of the Nervous System)

CNS glia:

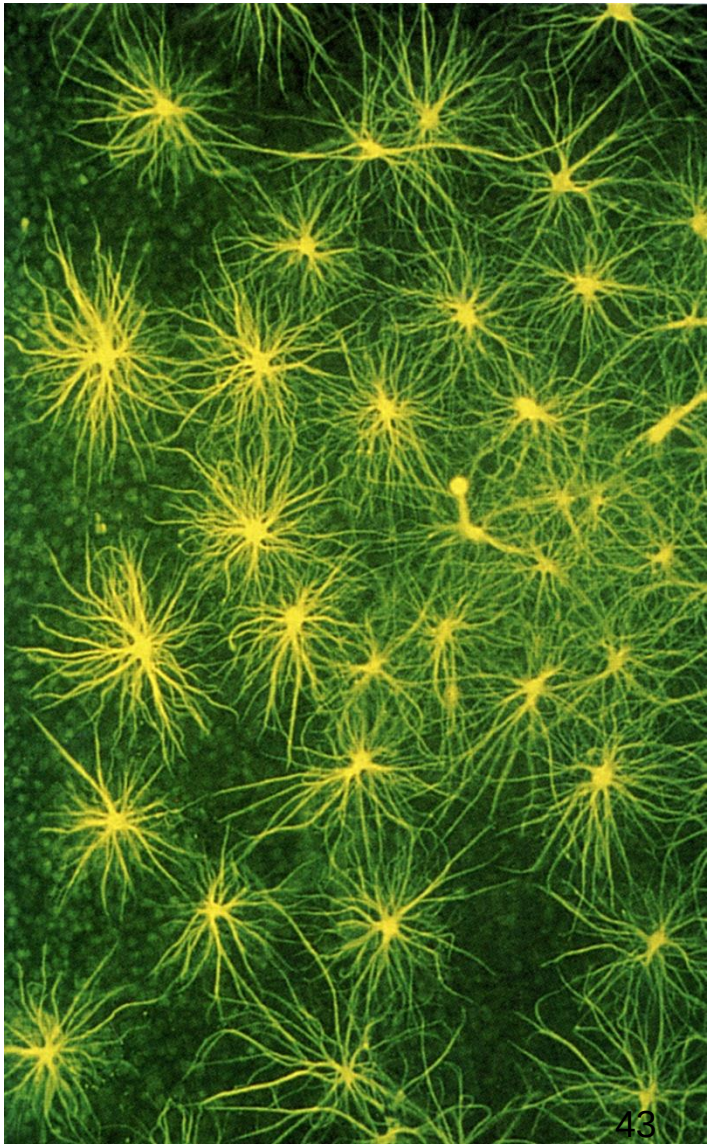
- Astrocytes – support the neurons
- Oligodendrocytes – myelinate axons
- Ependymal cells – line the ventricular system
- Microglia – housekeepers

PNS glia:

- Satelite cells – support the neurons
- Schwann cells – myelinate axons
- Macrophages – housekeepers

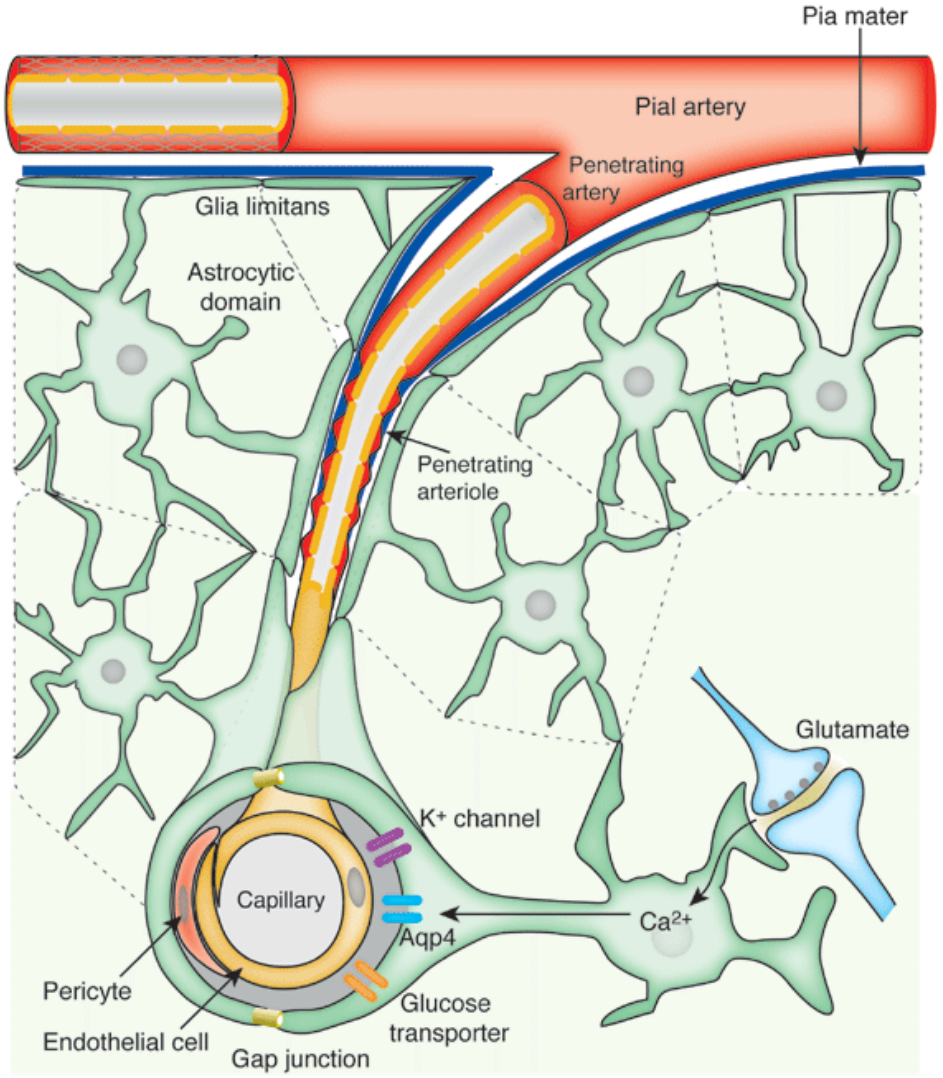
Astrocytes

- Star-shaped glial cells in the CNS
- Most abundant cell type of the brain and spinal cord
- Surround most neurons and blood vessels
- Contribute to the cellular scaffolding of the CNS

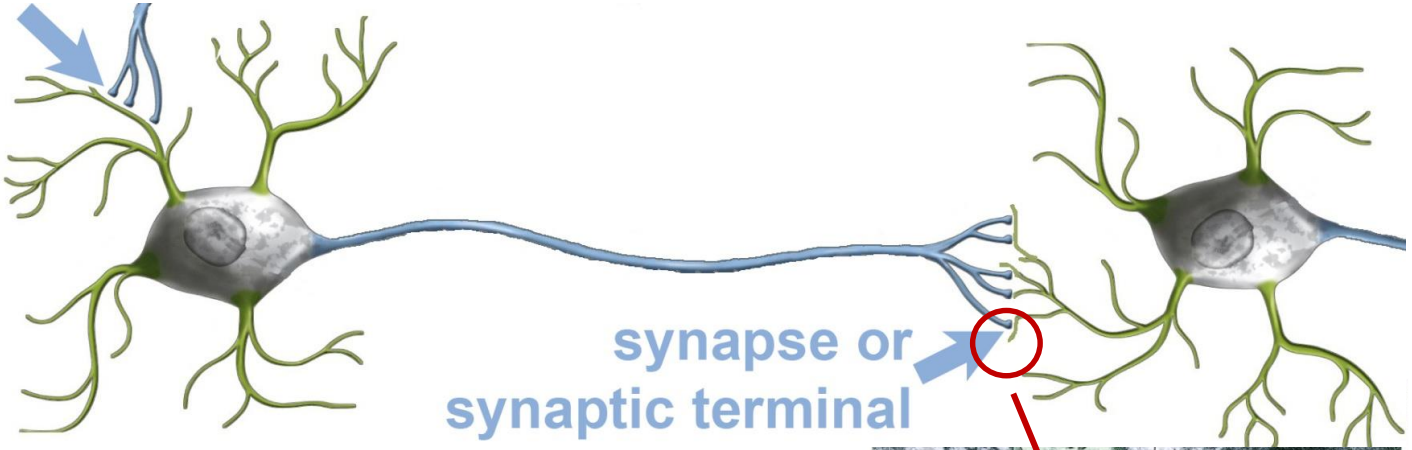


Astrocytes

- Mediate exchange between capillaries and neurons; contribute to the blood-brain barrier.



Astrocytes



- They remove and recycle neurotransmitter.
- They ‘insulate’ synapses from one another.
- They regulate the extracellular ionic environment of the neurons.