



## Biology Lecture 4 – The Eukaryotic Cell; The Nervous System

Examkrackers MCAT Comprehensive Course, Charles Feng  
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A EUKARYOTIC CELL HAS TWO “SIDES”: CYTOSOL/INSIDE VS. ER LUMEN/OUTSIDE

Chemicals in environment trying to reach cytosol, vice versa must pass through a membrane

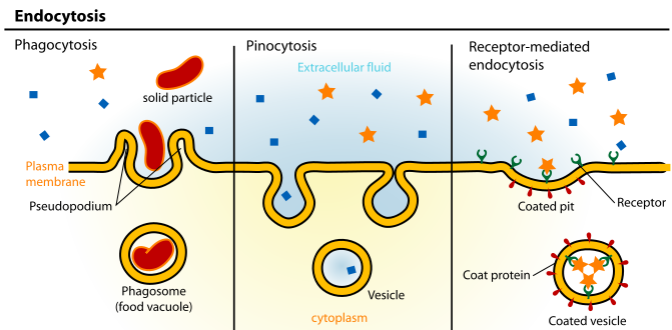
Chemicals in environment trying to reach ER lumen, vice versa don't have to pass through a membrane

**Nucleus** - Contains all DNA within cell

- Has double bilayer membrane called *nuclear envelope* which has *nuclear pores*
- *Nucleolus* responsible for creating rRNA

**Plasma Membrane** - Phospholipid bilayer

- *Endocytosis*: how cell gets substances from environment
- *Phagocytosis*: cell receptor detects particle, cell membrane protrudes outward to engulf it
- *Pinocytosis*: membrane invaginates, engulfs fluid
- *Exocytosis*: opposite of endocytosis



**Endoplasmic Reticulum** - Collection of membrane-bound sacs inside cell

- *Rough ER*: ER with ribosomes attached, directs new proteins into lumen where they can bud off into transport vesicles
- *Smooth ER*: Metabolizes sugars, creates fats (triglycerides, steroids, phospholipids), detoxes

**Golgi Apparatus** - Membrane bound sacs, responsible for transport inside cell

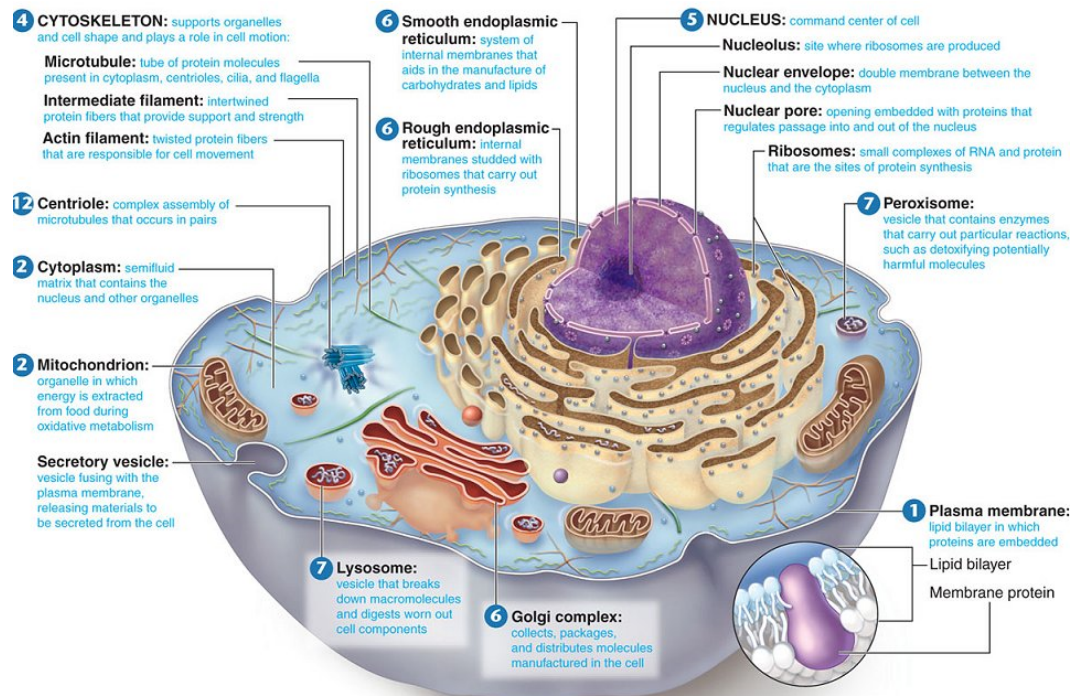
- Modifies proteins from rough ER, then packages & releases them to other parts of cell
- *Secretory vesicle*: a membrane bound vesicle filled with proteins, growth factors, or ECM components that will exit the cell through exocytosis

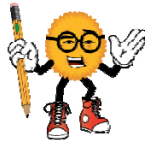
**Lysosome** - Special vesicle from Golgi that can digest macromolecules

- Has an acid environment (pH = 5)
- Fuses with *endocytotic vesicles* or old cell organelles to digest their contents
- Can rupture to kill cell (i.e. programmed cell death/*apoptosis*)

**Peroxisome** - Vesicles in cell that can break down hydrogen peroxide

- Reproduce themselves





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**Cytoskeleton** - Network of filaments that provide structural support + motility

**Microtubules:** hollow tubes made from *tubulin*

- Make up mitotic spindle, flagella, cilia
- **Centrosome:** (animal cells) contains two centrioles which create flagella/cilia, help w/ mitosis
- **Flagella/cilia:** 9+2 microtubules, or 9 pairs connected by *dynein* arms surrounding 2 more in the center

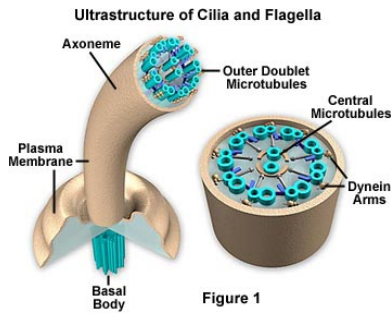
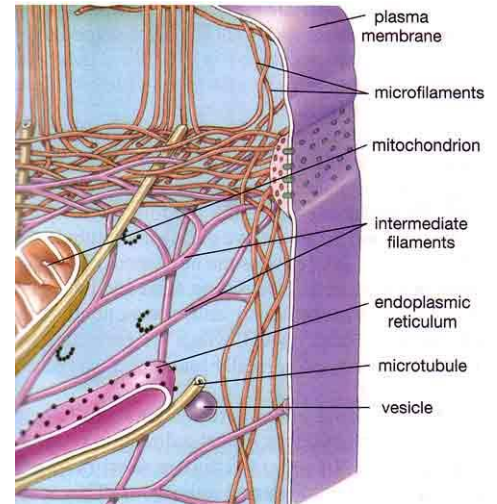


Figure 1



**Intermediate filaments:** can be *keratins*, *lamins*, etc.

- Used for cell adhesion, stabilization of organelles, neuron diameter

**Microfilaments:** made of *actin*

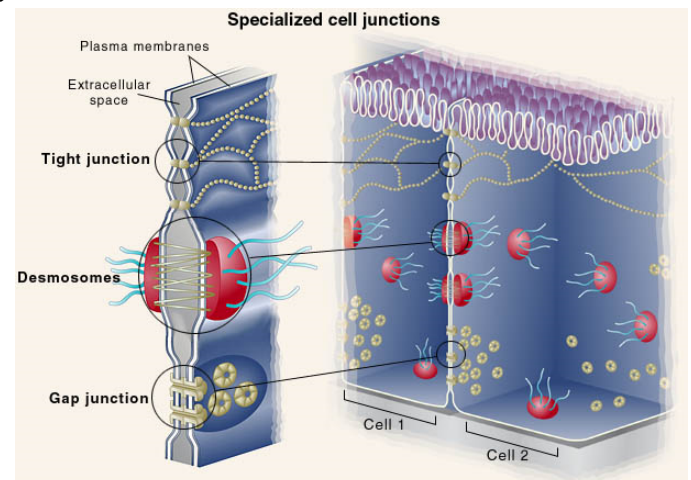
- Used for muscle contraction, cytoplasmic streaming, phagocytosis
- **Cytoplasmic streaming:** how amoeba move

**Mitochondria** - Provides power for cell

- Has double membrane, inner membrane folded into *cristae* and surrounds *matrix*
- **Endosymbiotic theory:** mitochondria was a prokaryote long ago, eaten by an eukaryotic cell
- Has own DNA and ribosomes, replicates independently (but many proteins come from cell)
- Mitochondrial DNA always comes from the mother

**Cellular Junctions** - How cells are connected to each other

- **Tight junction:** watertight seal, helps separate tissues i.e. inside/outside of intestines
- **Desmosomes:** joins cells at a single point, strong connections helping to hold cells together
- **Gap junctions:** tunnels connecting cells, allows flow of ions/molecules (esp. in heart cells)



**Extracellular Matrix** - Network of

- polysaccharides/proteins that hold tissues together
- Created + secreted by cells
- Contains structural proteins (i.e. collagen) and proteoglycans

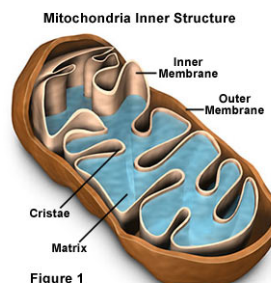
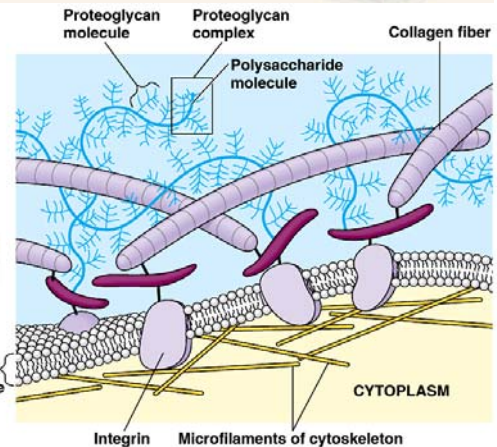


Figure 1



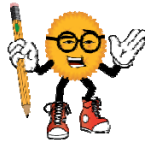
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**Cells → Tissues** (group of cells w/ specialized function)

→ **Organs** (group of tissues working together)

→ **Systems** (group of organs working together)





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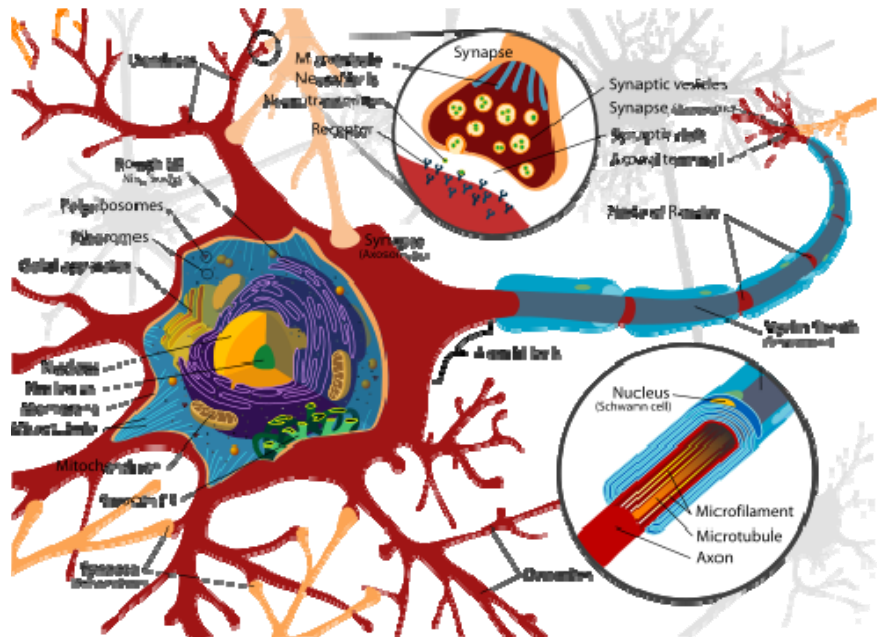
### Cellular Communication

- *Neuronal*: fast, direct, targets specific cells/tissues (nerves)
- *Hormonal*: slow, widespread, affects multiple cells/tissues throughout body (bloodstream)

**Paracrine System** - local hormones released by cells into interstitial fluid

**Neuron** - Transmits electrical signal from one cell to another

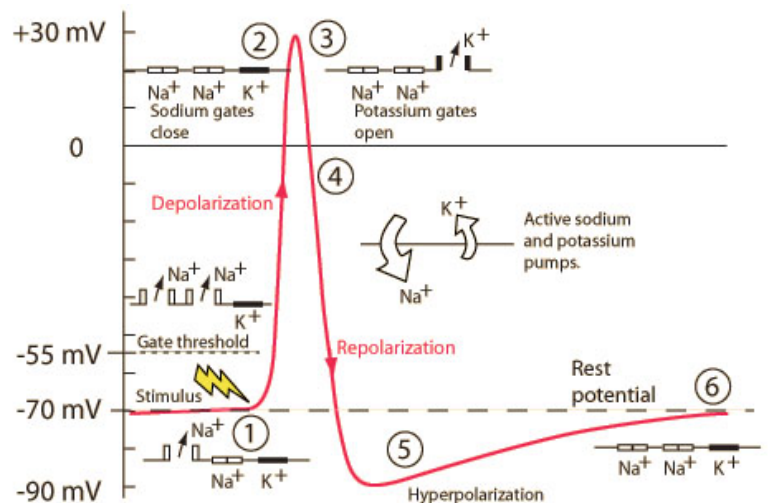
- Can't divide
- Doesn't depend on insulin for glucose transport (so +/- insulin levels have no effect)
- *Dendrite* receives signal, transfers to *axon hillock* which generates *action potential* down *axon*
- Axon is usually surrounded by *myelin sheath* with small gaps called *nodes of Ranvier*
  - *White matter*: axons with myelin
  - *Gray matter*: axons without myelin
- Myelin makes signal travel much faster (*saltatory conduction*: signal jumps from node to node)
- Myelin is produced by *Schwann cells* (PNS) or *oligodendrocytes* (CNS)

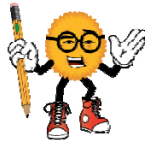


### Action Potential

All-or-nothing: fires when and only when voltage passes threshold

- 1) **Resting potential** established by  $\text{Na}^+/\text{K}^+$  pump
  - 3  $\text{Na}^+$  out, 2  $\text{K}^+$  in makes inside of cell have (-) charge relative to outside
  - Balance of  $\text{Na}^+/\text{K}^+$  pump and  $\text{Na}^+$  diffusing in makes constant resting potential
- 2) **Depolarization**: voltage-gated  $\text{Na}^+$  channels open,  $\text{Na}^+$  diffuses into cell
  - Inside of cell develops a (+) charge relative to outside (polarity flips)
- 4) **Repolarization**:  $\text{Na}^+$  channels close, voltage-gated  $\text{K}^+$  channels open,  $\text{K}^+$  diffuses out of cell
  - Inside of cell redevelops a (-) charge relative to outside
- 5) **Hyperpolarization**: inside of cell becomes more (-) than resting potential due to  $\text{K}^+$  flow
- 6) **Refractory period**:  $\text{K}^+$  channels close
  - $\text{Na}^+/\text{K}^+$  pump takes a while to bring cell back to resting potential
  - Cell can't have another action potential at this time





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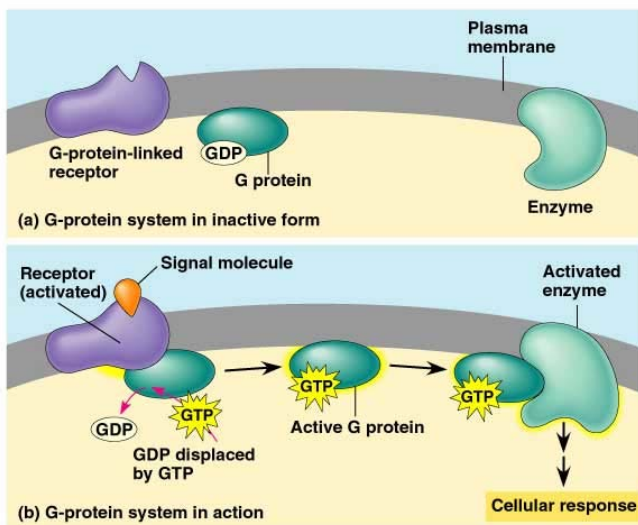
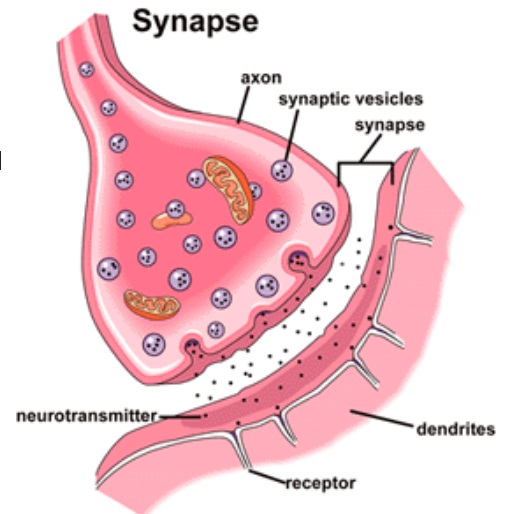
**Synapse** - How signal is transmitted between neurons

Electrical synapse: in cardiac/smooth muscle cells

- Gap junctions allow electrical signal to go through, much faster than chemical synapse

Chemical synapse: neurotransmitters released into synaptic cleft, diffuses to receptors on next cell

- Second messenger system*: *G protein* connected to receptor is activated when neurotransmitter binds, can subsequently open channels, activate proteins or cause gene transcription
- Can happen in only one direction, slowest part of neuron



### Types of Neurons

- Sensory/afferent*: carries signals from receptors to brain via interneurons
- Interneurons*: carries signal from neuron to neuron
- Motor/efferent*: carries signals from brain to muscles/glands

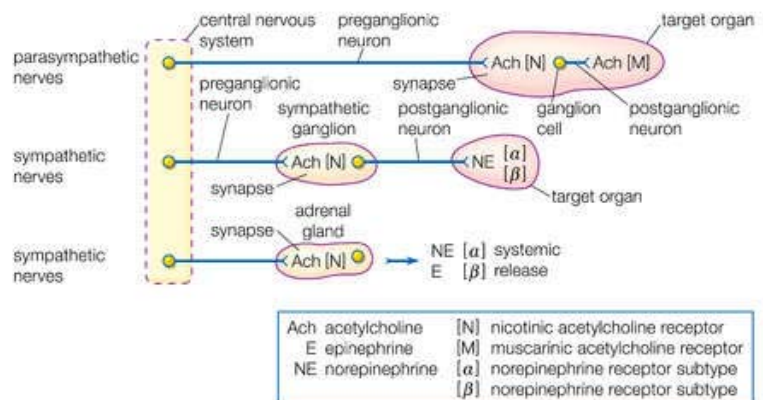
### Divisions of the Nervous System

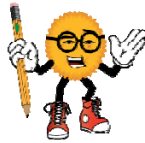
Central Nervous System (CNS): brain + spinal cord

- Lower brain*: medulla, hypothalamus, thalamus, cerebellum
  - Subconscious activities i.e. breathing, blood pressure, emotions, reactions to pain
- Higher brain*: cerebrum, cerebral cortex
  - Conscious activities i.e. memories, thoughts

Peripheral Nervous System (PNS): everything else

- Somatic Nervous System*: (voluntary) sensory + motor functions, responds to environment
  - Controls skeletal muscle, uses *acetylcholine*
- Autonomic nervous system*: (involuntary) controls smooth muscle, cardiac muscle,
  - Sympathetic ANS: "fight or flight", increases heart rate, increases blood flow to skeletal muscles, decreases blood flow to digestive system
  - Parasympathetic ANS: "rest and digest", opposite of sympathetic
  - Sympathetic uses *epinephrine/norepinephrine*, parasympathetic uses *acetylcholine*





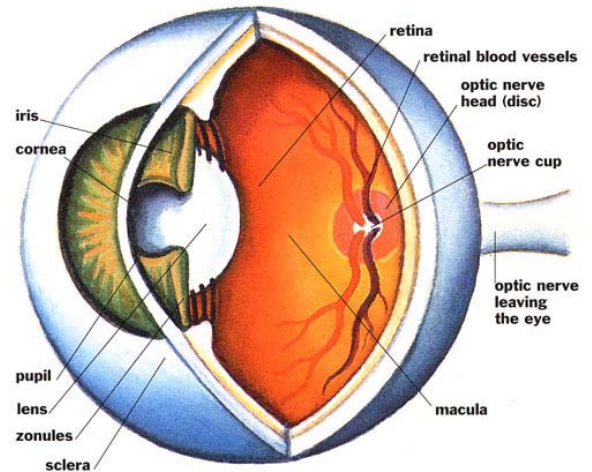
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### Eye

Light passes through the following (in order):

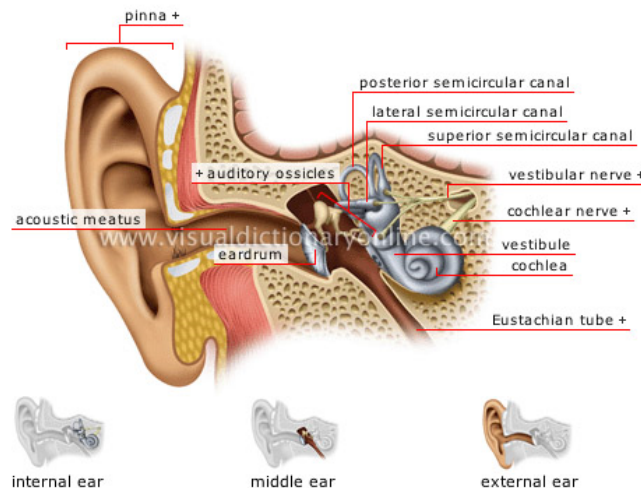
- **Cornea:** clear tissue made from collagen, bends light a bit
- **Pupil:** hole behind cornea, size controlled by iris muscles to let more/less light in
- **Lens:** focuses light on retina, controlled by *ciliary muscle*
- **Retina:** back of eye, contains rods/cones which are light-sensitive
  - Rods are more sensitive but can't distinguish colors
  - Cones less sensitive but have three types that detect colors



### Ear

Sound waves pass through the following (in order):

- (OE) Auditory canal
- (OE) Tympanic membrane (eardrum): vibrates to transfer sound to middle ear bones
- (ME) Malleus/incus/stapes: small bones that transfer sound to oval window
- (IE) Cochlea: receives pressure wave from oval window which affects cells inside
  - Hair cells inside organ of Corti: converts pressure to electrical signal to brain
  - Semicircular canals: three in xyz directions, responsible for balance



### Nose/Mouth

- Contains chemoreceptors that give things flavor
- We can taste bitter/sour/salty/sweet