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

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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

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

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 Na⁺/K⁺ pump
   - 3 Na⁺ out, 2 K⁺ in makes inside of cell have (−) charge relative to outside
   - Balance of Na⁺/K⁺ pump and Na⁺ diffusing in makes constant resting potential
2) **Depolarization**: voltage-gated Na⁺ channels open, Na⁺ diffuses into cell
   - Inside of cell develops a (+) charge relative to outside (polarity flips)
4) **Repolarization**: Na⁺ channels close, voltage-gated K⁺ channels open, 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 K⁺ flow
6) **Refractory period**: K⁺ channels close
   - Na⁺/K⁺ pump takes a while to bring cell back to resting potential
   - Cell can’t have another action potential at this time
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*
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