Ch. 3 – Cell Structure and Function

Basic Unit of Life
Multicellular Organisms

- Organisms = living things
- Multicellular = made of many cells
- Grow by making more small cells
- Elephants just have more cells than us!
Levels of Organization

Cells are the basic unit of life

- Organism
- Organ System
- Organs
- Tissues
- Cells
- Macromolecules
- Molecules
- Atoms
Cells Working Together

- Tissues
- Cells that work together
- Four basic types
Tissues Working Together

- Organs
  - Made up of 2 or more tissues working together
- Examples
  - Heart
  - Stomach
  - Leaf
  - Root
Organs Working Together

- Organ system
- Group of organs working together
- Digestive system
  - Break down food
Organ Systems Working Together

- Organisms = living things
- A group of organ systems working together
- Examples:
  - Boxelder bug
  - You!
Organization Summary

.Multicellular organisms
  ● Many cells
  ● Cells become specialized
  ● Very efficient
Structure and Function

● Structure
  ● The arrangement of parts
  ● How its put together

● Function
  ● The job of the part
  ● What it does and how it does it
3.1 Microscopes and Cells

- Micro = small
- Compound microscopes
  - 2 lenses
  - invented late 1500s
  - Zacharias Janssen usually gets credit
Cell Discovery

- **Robert Hooke**
  - English scientist 1665
  - First to describe cells

- **Looked at Cork (dead plant cells)**
  - Reminded him of rooms monks lived in (cells)
    - Gave the name cell
Cell Discovery

- Anton van Leeuwenhoek
- Dutch scientist 1674
- Looked at pond water
- Saw small organisms
  - “Animalcules”
  - Today called protists
Cell Theory

- One of first unifying concepts in biology and cells
- 1800s
- 3 German scientists
  - Schleiden
  - Schwann
  - Virchow
Cell Theory

- 1838
- Matthias Schleiden
- botanist (studies plants)
- Concluded all plants made up of cells
Cell Theory

- 1839
- Theodor Schwann
- Zoologist (studies animals)
- All animals made up of cells
Cell Theory

- 1855
- Rudolf Virchow
- Doctor
- All cells divide to produce more cells
Cell Theory

1) All organisms are made up of cells
2) Cell is the most basic unit of life
3) Cells come from existing cells
Two Kinds of Cells

1) Prokaryotes
   From Greek:
   Pro = before
   karuon = kernal or nut

2) Eukaryotes
   Eu = true
Prokaryotic Cells

- Ex:
  - Bacteria
  - Archaea
- No nucleus
- No membrane-bound organelles
- Unicellular
- Microscopic
  - 1-15 micrometers
Prokaryotic Cells

- Some have capsule
  - surrounds cell wall
  - Enables great clinging!
- Teeth, skin, food, etc.
- Some have flagella
2) Eukaryotic Cells

- **Nucleus**
- Membrane bound organelles
- Large cells (10x bigger than bacteria)

**How Big is a ... ?**

**Ex:**
- Protists
- Fungi
- Plants
- Animals
3.2 Cell Organelles

- Marcromolecules
- Perform specific functions
- Divide certain molecules into compartments
- Regulate timing of key events
Cytoskeleton

- **Cytoskeleton**
  - Web of proteins in cytoplasm
  - Acts like a skeleton
  - Constantly changing
  - Helps some cells move
Cytoskeleton

- Made of protein fibers
- 3 main types:
  - 1) Microtubules
  - 2) Intermediate Fibers
  - 3) Microfilaments
Cytoskeleton

1) Microtubules
   - Long, hollow tubes
   - Act as “tracks” for organelle movement
   - Give cell shape
   - Help cell divide
Cytoskeleton

2) Intermediate Fibers
   - Smaller
   - Give strength

3) Microfilaments
   - Smallest
   - Help cell move and divide
   - Important in muscle cells
Cytoplasm

- Fluid inside cell membrane
- Fills space around organelles
- Many chemical rxs here
- **Cytosol** – fluid portion
- Mostly water (Important solvent)
Nucleus

- **Nucleus**
  - large, round organelle
  - “Control center”
  - Controls making of proteins
  - Contains **DNA**
    - Deoxyribonucleic acid
    - Genetic material
Nucleus

- **2 Major Demands:**
  - 1) Must protect DNA
  - 2) DNA must be available at proper times
Nuclear Envelope (membrane)

- Covers nucleus
- Double membrane
  - Similar to cell membrane
- Contains **nuclear pores**
  - Small openings
  - Allow molecules to move between nucleus and cytoplasm
Nucleolus

- In nucleus
- Where ribosomes are made
- Dark area
Endoplasmic Reticulum

- (ER)
- “I-90”
- System of folded membranes
- Maze of passageways = lumen
- Protein and lipid production
  - Occur inside and on surface
Endoplasmic Reticulum

- **Rough ER (RER)**
  - Has ribosomes on surface
    - Proteins made and then go into ER

- **Smooth ER (SER)**
  - No ribosomes
  - Makes lipids
  - Break down drugs and alcohol
Ribosomes

- Made BY nucleolus
- Made OF proteins and RNA
- Make proteins
- “protein factories”
- In cytoplasm and on RER
Golgi Apparatus

- “Post office”
- Processes, sorts and deliver proteins
- Makes changes to proteins
- Packages proteins
Golgi Apparatus

- Modifies proteins or lipids
- Pinches off a piece of membrane and forms small bubble-like structure = **Vesicle**
Vesicles

- Small sac containing materials
  - Moves materials into or out of cell
  - Isolate and transport specific substances
    - Ex: proteins
  - Short lived
  - Formed and recycled as needed
Mitochondria

- **Mitochondria**
  (Mitochondrion = singular)
- “Powerhouse”
- Makes ATP
  - Energy!
- Breaks down glucose
Mitochondria

- In most eukaryotic cells
- ~ size of bacteria
- Double membrane
- Inner membrane = many folds
  - Increases surface area
- Have own ribosomes and DNA
  - Can divide
Vacuole

- “Walk-in closet”
- Type of vesicle
- When full = support
- Central Vacuole
  - Plants
  - Support
Lysosomes

- Contain digestive enzymes
- Protects cell
- Get rid of wastes
- Break down materials
  - Food
  - Worn-out parts
Lysosomes

- Mainly in animal cells

Thinker:
- Why is it important for the double membrane?
Centrioles

- Made of microtubules
- Arranged in a circle
- Divide DNA during cell division
- NOT in plant cells
- Two perpendicular centrioles = Centrosome
Flagella

- Flagellum = singular
- Long hair-like structure
- Made of microtubules
- Enable cell movement
Cilia

- Singular = cilium
- Short hairlike structure
- Made of microtubules
- Helps sweep liquid across cell's surface
Cell Wall

- Plants, fungi, algae, and most bacteria
- Thick, rigid
  - Provides support
  - Stick to other cell walls
Cell Wall Composition

- **Fungi** (Ex: yeasts, mushrooms)
  - chitin
- **Bacteria**
  - peptidoglycan
- **Plants and algae**
  - cellulose
Chloroplasts

- “Sugar Factories”
- **Thylakoids** – stacks of disc-shaped sacs
  - Contain chlorophyll
    - Green
  - Site of photosynthesis
Chloroplasts

- In plants and green algae
- Like mitochondria
  - Two membranes
  - Own DNA and ribosomes
Chloroplasts and Mitochondria
Plant Cell Structure
Animal Cell Structure
3.3 Cell Membrane

- “Gatekeeper”
- All cells have
- Acts as boundary
- Controls what enters and leaves cell
Cell Membrane

- Double layer of phospholipids interspersed with other molecules
  - Ex:
    - Steroids
    - Proteins
Cell Membrane

- **Phospholipids**

- 1) “Head” = Glycerol and phosphate group
  - Charged, polar
  - *Hydrophilic* - Water loving (H-bonds)
  - Face outward
Cell Membrane

- **Phospholipids**
- 2) “Tail” = 2 fatty acid chains
  - **Hydrophobic** - Water fearing
  - Face inside
  - Protected from water
Cell Membrane

- Other molecules:
- Cholesterol
  - strengthen
- Proteins
  - Act as passageway
- Carbohydrates
  - ID tags
Cell Membrane

- **Fluid Mosaic Model**
  - Describes arrangement of molecules in cell membrane
  - Flexible like a fluid
  - Molecules vary in arrangement
Cell Membrane

- **Selective permeability** – allows only some materials across
- “semipermeable”
- Allows homeostasis
- Small, nonpolar molecules easily pass thru membrane
- Small, polar molecules use proteins
- Large molecules use vesicles
Chemical Signals across the Membrane

Membrane may secrete molecules
May contain carbohydrates
Both act as communication signals
Cells must communicate to coordinate growth and metabolism

Cells far apart

- Communicate indirectly
  - Use signal molecules
    - Ex: Hormones
Cells must distinguish important information from unimportant
Cell Surface Proteins
Receptor

- Protein
- Detects signal molecule
  - Performs action
- Binds to specific molecules
  - Ligand – molecule a receptor binds to
Receptor Proteins

• Bind to and fit specific signal molecule

• Causes change in the cell
  • 1) change in permeability
  • 2) act as second messenger
  • 3) Enzyme action
Second Messengers

- **Receptor proteins** may cause formation of second messenger
  - In cytoplasm
  - Acts as signal molecule
    - Amplifies signal of first messenger
    - Changes the cell
      - Activate enzymes
      - Changes permeability
Enzyme Action

● Receptor proteins
  ● May act as an enzyme
  ● Activate other enzymes
  ● Cause changes in cell function
  ● Ex: Drugs affect binding of signal molecules and receptor proteins
Intracellular Receptor

- Located inside cell
- Bound by molecules that can cross membrane
Membrane Receptor

- Binds to molecules that can't pass thru membrane
- Sends message to interior
- Molecule changes shape
Think about it:

How do intracellular receptors differ from membrane receptors?

Intra: - located within cell

Bind to molecules that cross directly through

Membrane: bind to molecules that cannot pass

Transmit message by changing shape
Materials pass thru cell membrane

Cells need to take in:
  - Oxygen
  - Nutrients

Cells need to get rid of:
  - Carbon dioxide
  - Wastes
Membrane Structure and Function

● Structure
  ● Made of proteins and lipids
  ● Lipid bilayer

● Function
  ● Controls what enters and leaves the cell
  ● Selectively permeable
Moving Small Particles

- Some particles cross thru membrane
  - Small lipids
  - Nonpolar
- Some particles use passageways
  - **Channels**
    - Made of protein
Cell Membrane Transport

- Movement of materials through the membrane
  - Membrane is *Semipermeable*

Types of transport:
- **Passive:**
  - Without cell energy
- **Active:**
  - With cell energy
Concentration Gradient

- A difference in concentration across a space
- Areas of:
  - Higher concentration
  - Lower concentration
Passive Transport

- Particles move across cell membrane
  - Go from areas of higher to lower concentration
- No cell energy required
- Types:
  - Diffusion
  - Osmosis
  - Facilitated diffusion
Passive Transport

- Movement of particles from areas of greater concentration to areas of lesser concentration
  - Move *down* concentration gradient
  - No ATP!
  - Natural flow
    - Like going down stream
Diffusion

- Particles move
  - Constantly
  - Randomly
  - Tend to spread out
    - Crowded to less crowded areas
Dynamic Equilibrium

- "Goal"
- **Equilibrium**
  - Concentration same throughout
- **Dynamic** - Molecules **Do not stop moving**
  - but **No net motion**
Diffusion Example
Osmosis

- Diffusion of water across a cell membrane
  - Water = small molecule
    - Fits through membrane pores
Osmosis

- Important!
  - Aqueous solutions inside and outside of cell
Osmotic Systems

- Compare solution outside and inside the cell
- Three types of solutions:
  - Hypertonic
  - Hypotonic
  - Isotonic
- Solutions consist of:
  - Solute
    - Dissolved “Stuff”
  - Solvent
    - Does the dissolving
    - Often = Water
Isotonic Solutions

- Iso = “Equal”
- Solute concentration equal inside and outside of cell
  - No concentration gradient
- Water moves into and out of cell, but no net movement of water
Hypotonic Solutions

- Hypo = “below”
- Solution outside cell has **low** concentration of **solute**
- High concentration of water
  - Concentration gradient
- Net movement of water **into** the cell
Hypotonic Solutions

- Cells plump up
  - Cells look like hippos
- Ultimate hypotonic solution = distilled water
Hypertonic Solutions

- Hyper = “above”
- Solution outside cell with high concentration of solute
  - Low concentration of water
  - Concentration gradient
- Net movement of water out of the cell
Blood Cells and Osmosis

- RBC placed in pure water
  - Cell would swell and burst!
Cells and Osmosis
Osmosis Matters to Cells
Osmosis Matters to Cells
Facilitated Diffusion

- Passive transport that uses *Carrier proteins*
  - Bind to substance
  - Carry it across membrane
  - Release

- Moves aa and sugars
Facilitated Diffusion
Diffusion in Ion Channels

- Ions
- Ex: Na\(^+\), K\(^+\), Ca\(^{+2}\), Cl\(^-\)
- Important for cell function
  - Nerve cells
    - Nerve impulses
  - Muscle cells
    - Muscle contractions
Ion Channel

- Transport protein with a polar pore through which ions can pass
- Allows ions to cross the cell membrane
  - Avoids the nonpolar lipid bilayer
Ion Channels

- Some always open
- Some opened and closed like a gate
  - Open or close in response to different stimuli
    - Membrane stretching
    - Electrical charges
    - Specific molecules
Active Transport

- Cell energy required
- Particles go from areas of lower to higher concentration
  - Particles move **up** concentration gradient
  - Move **against** normal flow
Active Transport

Different kinds:

1) Solute pumping
   - Uses Carrier proteins
   - Ex: Sodium-Potassium Pump

2) Bulk transport
   - Use vesicles
   - Exocytosis
   - Endocytosis
Sodium – Potassium Pump

- Three sodium ions out
- Two potassium in
- Against conc. gradients
- Needs ATP
Sodium – Potassium Pump

- Two important functions:
  - 1) Prevents excess $\text{Na}^+$
    - If $\text{Na}^+$ came into cell water would come in too
      - Cell might burst
  - 2) Maintains concentration gradients
    - Helps to move other substances
Moving Large Particles

- Use vesicles
- Can't fit thru protein channels
- Active Transport
  - Ex:
    - Endocytosis
    - Exocytosis
Endocytosis

- “Endo” = into/within
- “Cyto” = cell
- Cell membrane pouches in
- Brings particles into cell
Exocytosis

- “exo” = out of
- Encloses a large particle in a vesicle
- Brings particle to cell membrane
- Vesicle fuses with membrane
- Particles released outside of cell
Review of Active and Passive Transport

- **Passive transport**
  - No ATP needed
  - Down concentration gradient
    - Greater to lesser conc.

- **Active transport**
  - Requires ATP
  - Against concentration gradient
    - Lesser to greater conc.