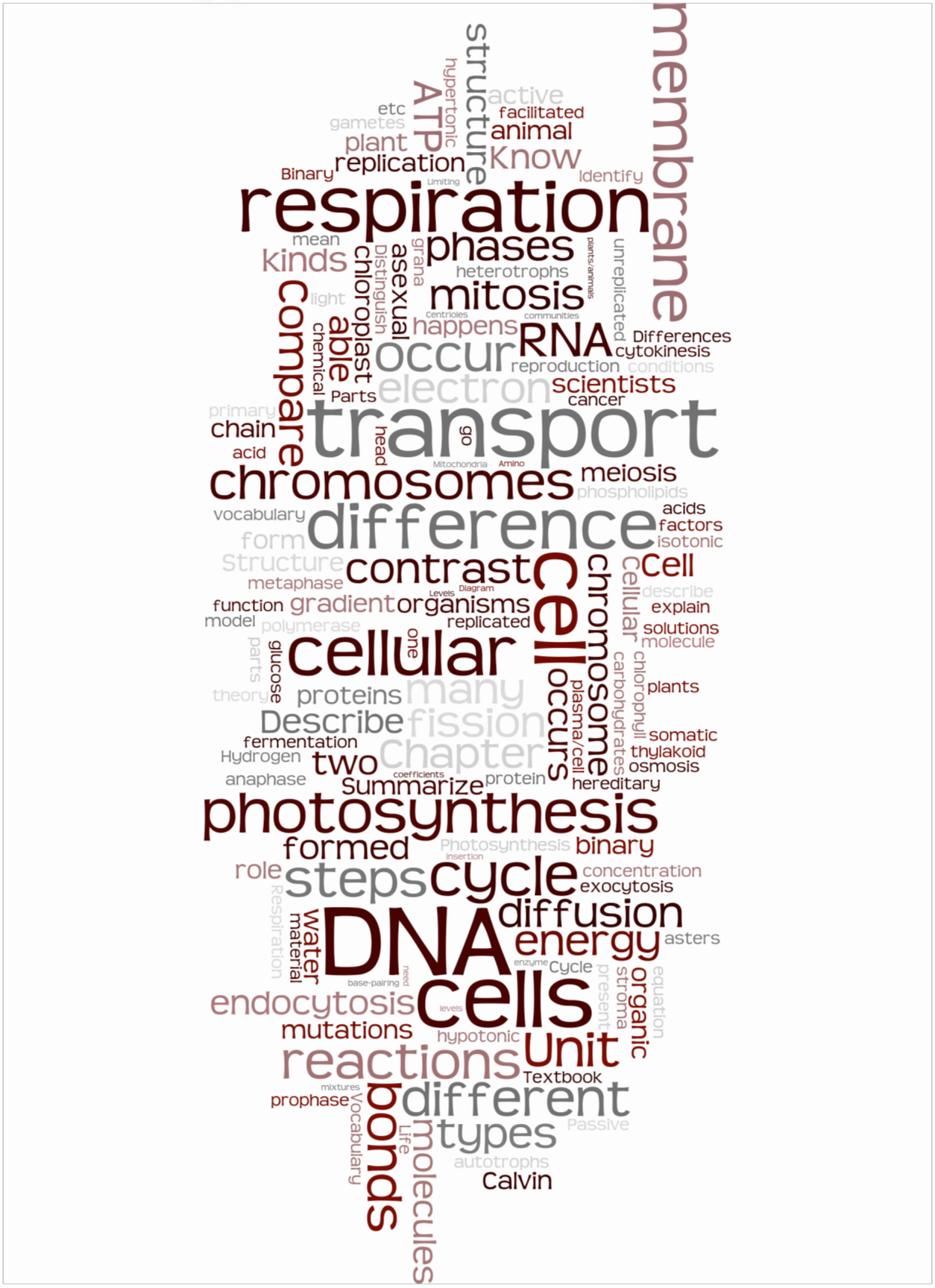
Adv. Biology Midterm Study Guide 09-10



Units of Study

The midterm consists of 6 units. **(with the page that each section starts on)**

Intro. & Ecology Unit

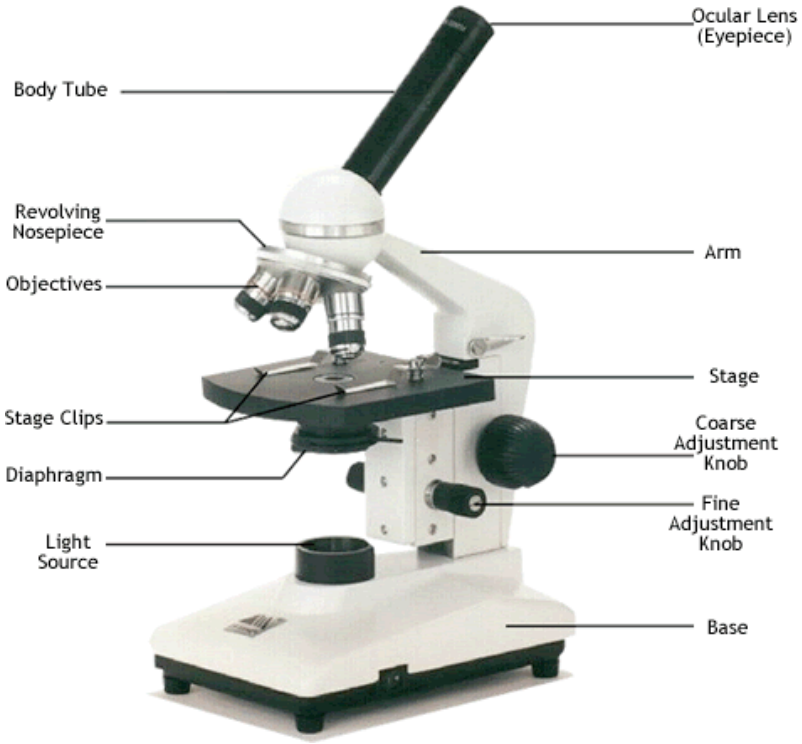
- **Textbook: Chapters 1, 2, 3, and section 4.1**
- Zebra Mussels -
  - An organism that originated in Europe that is clogging up waterways in the U.S.
  - It is cream colored with brown stripes and is headless, hairless, and has no hands.
  - They came on cargo ships from Europe crossing the Atlantic. The ship emptied its ballast, along with the zebra mussels in Lake St. Clair.
  - Their population exploded because they didn't have any predators, the female zebra mussel produced 400 zebra mussels each year, and they are so small.
  - They are a problem because they clog pipes and power lines.
  - They can be called an **invasive species** because their mass reproduction provides issues with overpopulation. They invaded our area.
- Scientific method -
  - Methods used to gather information and to answer questions.
  - Biologists all use similar scientific methods to gather information and answer questions. The biologists observe and infer throughout the entire process.
- Metric System -
  - Uses units with divisions that are powers of ten.
  - The system is called the International System of Units, commonly known as SI. To make communication easier, most scientists use the metric system when collecting data and performing experiments.
  - The SI units most used in biology are meter (length), gram (mass), liter (volume) and second (time).
- Characteristics of Life -
  - Made of one or more cells - The cell is the basic unit of life. It is a basic unit of structure and function in all-living things. All organisms are made up of one or more cell. Humans and plants are multicellular, having many cells.
  - Displays organization - *Organization* - arranged in an orderly way. The levels of organization in biological systems begins with atoms and molecules and increase in complexity. Each organized structure has a specific function.

- Grows and develops - *Growth* results in an increase of mass to an organism, and, in many, the formation of new cells and new structures. *Development* is the process of natural changes that take place during the life of an organism. It results in different abilities.
- Reproduces - Many living things are the result of *reproduction*--the production of offspring. Reproduction is not an essential characteristic for individual organisms. *A species* is a group of organisms that can breed with one another and produce fertile offspring. If the last individual in a species does not reproduce, the species become extinct.
- Responds to stimuli - Reactions to internal and external stimuli are called *responses*. Anything that is a part of the environment and causes some reaction by the organism is called a *stimulus (*plural *stimuli*. Being able to respond to the environment is critical for an organism's safety and survival; otherwise it won't be able to reproduce.
- Requires energy - Energy is required by living things to fuel their life processes. Living things get their energy from food. Most plants and some unicellular organisms use the energy from sunlight to make their own food and fuel their activities. Other organisms can use the energy in chemical compounds to make their food. Organisms that can't make their own food, such as animals and fungi, get energy by consuming other organisms. Some of the energy that an organism takes in is used for growth, development, and maintaining homeostasis. However, most of the energy is transformed into thermal energy and is radiated to the environment as heat.
- Maintains homeostasis - All organisms keep internal conditions stable to maintain life by a process called *homeostasis*. For example, humans perspire to prevent their body temperature from rising too high. If anything happens within an organism that affects it's normal state, processes to restore the normal state begin. If homeostasis is not restored, it can result in death.
- Adaptations evolve over time - *Adaptations* are inherited changes that occur over time that help the species survive.

- Microscope
  - History - Before microscopes were invented, people believed that diseases were causes by curses and supernatural spirits. Microscopes enabled scientists to view and study cells.
  - Types -
    - Simple Light Microscope - the first person to record looking at water under a microscope was Anton van Leeuwenhoek. He uses a simple light microscope.
    - Compound Light Microscope - uses a series of lenses to magnify objects in steps. Objects can be magnified up to 1500 times.

- Electron Microscope - Allowed scientists to see structures inside the cell that they couldn't see before. This microscope uses a beam of electrons, rather than light to magnify structures up to 500,000 times.

- Parts



- What is ecology? - Ecology is the study of interactions that take place between organisms and their environment.
- Biotic Factors - the **living factors** in an organism's environment. For example, in the habitat of a salmon the biotic factors include all of the organism that live in the water, such as other fish, algae, frogs, and microscopic organisms. Organisms that live on the land adjacent to the water might be biotic factors for the salmon.
- Abiotic Factors - the **nonliving factors** in an organism's environment. The abiotic factors for different organism vary across the biosphere, but organisms that live in the same geographic area might share the same abiotic factors. These factors might include temperature, air or water currents, sunlight, soil type, rainfall or available nutrients. For example, the abiotic factors for salmon might be the temperature range of the water, the pH of the water, and the salt concentration of the water.
- Levels of organization in an ecosystem

  - Organism
  - Population
  - Biological community
  - Ecosystem
  - Biome
  - Biosphere
- Niches - the role or position than an organism has in its environment. It is how it meets its needs for food.
- Habitats - an area where an organism lives.
- Predation - the act of one organism consuming another organism for food. The organism that pursues another organism is the predator, and the organism that is pursued is the prey.
- Prey
- Scavengers - eat animals that have already died.
- Decomposers - break down the complex compounds of dead and decaying plants and animals into smaller molecules that can be more easily absorbed.
- Autotrophs - an organism that collects energy from sunlight or inorganic substances to produce food. Autotrophs are the foundation of all ecosystems because they make energy available for all other organisms in an ecosystem.
- Heterotrophs - an organism that cannot make its own food and feeds on other organisms. They are called consumers.
- Symbiotic relationships
  - Parasitism - a relationship in which one organism benefits at the expense of another organism. Parasites can be external, such as ticks and fleas, or internal, such as bacteria, tapeworms, and roundworms.
  - Commensalism - a relationship in which one organism benefits and the other organism is neither helped nor harmed.
  - Mutualism - the relationship between two or more organisms that live closely together and benefit from each other.
- Food chains - a simple model that shows how energy flows through an ecosystem. For example in a typical grassland food chain, the flower uses energy from the Sun to make its own food. The grasshopper gets its energy from eating the flower. The mouse gets its energy from eating the grasshopper. Finally, the snake gets its energy from eating the mouse. Each organism uses a portion of the energy it obtains from the organism it eats for cellular processes to build new cells and tissues. The remaining energy is released into the surrounding environment and no longer is available to these organisms.
- Food webs - a model representing the many interconnected food chains and pathways in which energy flows through a group of organisms. Feeding relationships usually are more complex than a single food chain because most organisms feed on more than one species. Birds for instance, eat a variety of seeds, fruits, and insects. The model most often used to represent the feeding relationship in an ecosystem is a food web.
- Ecological pyramids

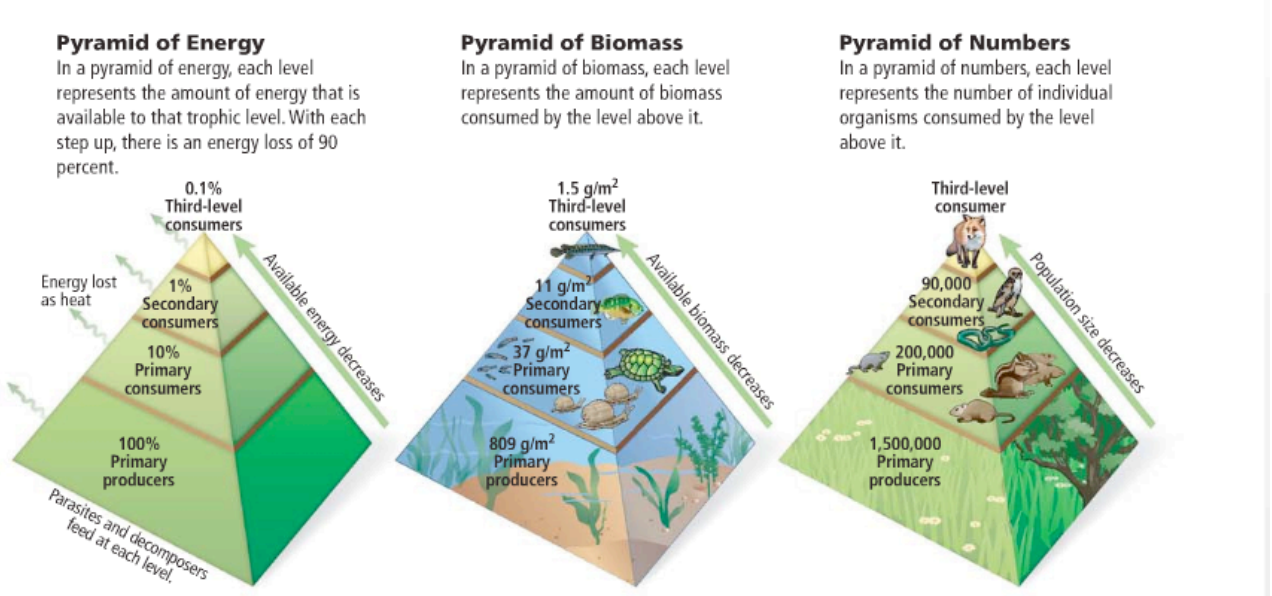
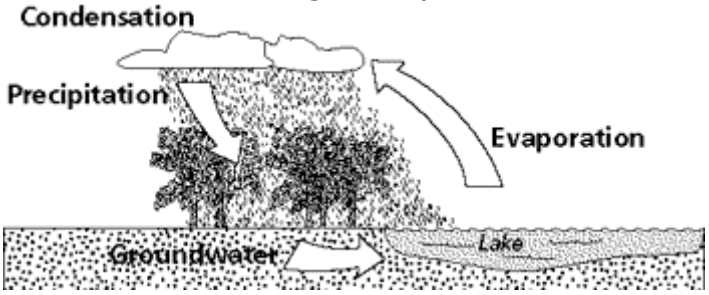


Figure 2.15 Ecological pyramids are models used to represent trophic levels in ecosystems.

Ecological pyramids Another model that ecologists use to show how energy flows through ecosystems is the ecological pyramid. An ecological pyramid is a diagram that can show the relative amounts of energy, biomass, or numbers of organisms at each trophic level in an ecosystem.

- Energy - illustrates that the amount of available energy decreases at each succeeding trophic level. The total energy transfer from one trophic level to the next is only about 10% b/c organisms fail to capture and eat all the food energy available at the trophic level below them.
- Biomass - the total weight of living matter at each trophic level. The pyramid represents the total weight of living materials available at each trophic level.
- Numbers - shows that population size decreases at each higher trophic level.

- Cycles:
  - Water - water moves in a cycle between organisms on land, the land itself, and the atmosphere. All organisms need water. Plants need water because a plant splits water to produce oxygen. The events of the water cycle are evaporation, condensation, transportation, precipitation, and run off.



  - Nitrogen - the largest concentration of nitrogen is found in the atmosphere, however it can't be readily used by plants and animals. Nitrogen Fixation is the process of capture and conversion of nitrogen into a form that is useable by plants. Consumers get nitrogen by eating plants or animals that contain nitrogen. (Dissolved CO_2 - Decomposers through cellular respiration. **OR** Living thing goes through cellular respiration and dissolves CO_2.) Nitrogen is returned to the soil when: an animal urinates, an organism dies - decomposers transform the nitrogen and into ammonia. Organism in the soil convert ammonia into nitrogen compounds that can be used by plants.

  - Phosphorous - Phosphorus is essential for the growth and development of organisms.
  - There are two cycles - short and long term
    - Short term - phosphates are cycled from the soil to producers and then to consumers. When organisms die, decomposers return the phosphorous to the soil where it can be used again. Phosphorus moves from short to long term though precipitation and sedimentation to form rocks.
    - Long Term - weathering or erosion of rocks that contain phosphorus adds phosphorus to the cycle. Phosphorous in the form of phosphates may only be present in small amounts in soil and water.
  - Carbon - The process of photosynthesis and respiration causes carbon to cycle through the environment. Organisms that respire releases carbon dioxide and water - producers use the carbon dioxide and water for photosynthesis. When decomposers break down dead and decaying organism, they go through cellular respiration and release carbon dioxide. Burning fossil fuels release carbon dioxide back into the environment.
- Succession:
  - Primary - the colonization of barren land by communities of organisms. It takes place on land where there are no living organisms.
  - Secondary - the sequence of changes that takes place after an existing community is severely disrupted in some way. It occurs in areas that previously contained life, and on land that still contains soil. It takes more time than primary succession to reach a climax community.
- Climax communities - a stable mature community that undergoes little or no change in species.
- Pioneer species - the first species to take hold in an area like primary succession.
- Biomes: where they are located, what lives there (primary plants/animals), characteristics and climate (precipitation and temperature)
  - **See Notes Section 3.2**
- Population growth:
  - Linear - populations of organisms do not experience linear growth, rather it starts out slowly and resembles a J-shaped curve.
  - Exponential (J-shaped) - as a population gets larger, it also grows at a faster rate. The graph of a growing population starts out slowly, then begins to resemble a J-shaped curve. The initial increase in the # of organism is slow b/c the # of reproducing individuals is small. Soon the rate of pop. growth increases b/c the total # of individuals that are able to reproduce ahs increased.
  - S-shaped curves - limiting factors such as availability of food, disease, predators, or lack of space will cause population growth to slow. Under these pressures, the population may stabilize in an S-shaped curve.
- Limiting factors - such as availability of food, disease, predators, or lack of space will cause population growth to slow
- Carrying capacity - the # of organisms of one species that an environment can support indefinitely is its carrying capacity. When a pop. overshoots its carrying

capacity, then limiting factors may come into effect and deaths begin to exceed births and the pop. falls below carrying capacity.

- Density dependent factors - # of individuals in a given area. They include disease, competition, predators, parasites, and food. (People live close together.)
- Density independent factors - can affect all populations, regardless of their density. Most are abiotic factors such as temperature, storms, floods, drought, and major habitat disruption.
- Competition - a density-dependent factor. When only a few individuals compete for resources, no problem arises. When a population increases to the point at which demand for resources exceeds the supply, the population size decreases.
- Stress - When populations of certain organisms become crowded individuals may exhibit symptoms of stress. Animals can exhibit a variety of stress symptoms that include aggression, decrease in parental care, decreased fertility, and decreased resistance to disease. They become limiting factors for growth and keep populations below carrying capacity.

Chemistry of Life Unit

- **Elements**
  - Pure substance that cannot be broken down into other substances by physical or chemical means.
  - One type of atom
  - 100 known, 92 unknown
  - Each has unique name and symbol
  - Periodic table- organized into rows(periods) and columns(groups)
    - Elements in the same group have similar chemical and physical properties

- **Structure of an atom and energy levels**
  - Building blocks for matter
  - Nucleus- neutrons(particles have no charge) and protons(positively charged particles) are located at the center of an atom
  - Electrons- negatively charged particles that are located outside the nucleus. Move around nucleus in energy levels.
    - 1 energy level - 2
    - 2 energy level - 8
  - Structure of an atom is the result of attraction between protons and electrons.
  - Contain equal number of protons and electrons, so charge is 0.

- **Ions: positive and negative, how are they formed?**
  - An atom that has lost or gained one or more electrons and carries an electric charge

- **Isotopes: what are they**
  - Atoms of the same element that have different number of neutrons
  - Changing the number of neutrons can affect the stability of the nucleus (decay or break apart)

- Radioactive isotopes- give off radiation when break apart
  - Half life- time it takes for half of carbon-14 to decay

- **Compounds and molecules, mixtures and solutions**
  - Compounds- a substance that is composed of atoms of two or more different elements that are chemically combined ex: table salt (NaCl)
  - Properties of compounds are different from those of their individual elements
    - Hydrogen-gas
      Oxygen-gas
      H2O- water (liquid)
  - Molecules-A group of atoms held together by covalent bonds and they have no overall charge
  - Mixtures- a combination of substances in which the individual components retain their own properties.
  - Solutions- mixture in which one or more substances(solutes) are distributes evenly in another substance (solvent)
    - The more solute that is dissolved in a substance the greater the concentration or strength of the solution

- **Solute and solvent**
  - Solvent- a substance in which another substance is dissolved
  - Solute- the substance that is dissolved in the solvent

- **Covalent bonds and ionic bonds**
  - Chemical bonds-Force that hold substances together
    - A partially filled energy level is not as stable as an energy level that is empty or completely filled
    - Become stable by either losing or gaining a electron
    - Store energy and the breaking of chemical bonds that provide energy for processes of growth, development, adaptation, and reproduction in living things
  - Covalent bonds- form when electrons are shared
  - Ionic Bonds- an electrical attraction between 2 oppositely charged atoms or groups of atoms called ions
    - Ion- an atom that has lost or gained one more electrons and carries and electrical charge
    - Metal donate electrons and nonmetals accept elections
    - Have higher melting points

- **Hydrogen bonds**
  - Attraction of opposite charges between hydrogen and oxygen, week bond

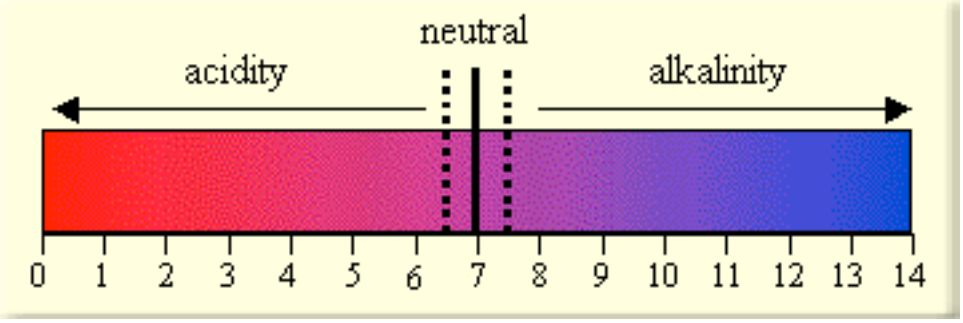
- **Chemical reactions: reactant and products, formulas, symbols, subscripts and coefficients, equilibrium, conditions for chemical reactions**
  - Occur when bonds between atoms are formed or broken, causing substances to combine and recombine as different molecules

- Clues that a chemical reaction has taken place include the production of heat or light, and formation of a new gas, liquid, or solid
  - Metabolism- all the chemical reactions that occur within a organism
- Written as chemical equations that use symbols and formulas
  - The number of molecules of each substance is indentified by the number that comes before the molecule
  - The subscript tell you how man atoms of each element are there
  - Reactants-starting substances (left side)
  - Products-substances formed during the reaction (right side)
  - Each equation must show a balance of mass which means that the number of atoms of each element on the reactant side must equal the number of atoms on the same element on the product side.
- A reaction is at equilibrium when reactants and products form at the same rate
- Bond energy is the amount of energy that breaks a bond
  - Energy is added to break bonds
  - Energy is released when bonds form
- In every chemical reaction, there is a change in energy due to the making and breaking of chemical bonds as reactants for products

- **Activation energy**
  - The amount of energy that needs to be absorbed to start a chemical reaction

- **Endothermic/exothermic reactions**
  - Exothermic- it releases energy in the form of heat
    - Excess energy is released by the reaction
  - Endothermic- it absorbed heat energy
    - Energy is absorbed by the reaction to make up the difference

- **pH: Acids and bases – scale/ions formed**
  - chemical reactions can occur only when conditions are right
  - A reactions may depend on:
    - Energy availability
    - Temperature
    - Concentration of a substance
    - pH of the surrounding environment
  - pH-is a measure of how acidic or basic a solution is
  - acid- any substance that forms hydrogen ions in water
  - base- any substance that forms hydroxide ions in water



- **Enzymes, substrate, catalyst, active site, lock and key, induced fit model, buffers; how enzymes are named; conditions for enzyme function**
  - Enzyme-type of protein found in all living things that increases the rate of chemical reactions-catalyst
    - Involved in almost all metabolic processes
    - Enables a molecule called substrates to undergo a chemical change and form a product
    - Enzymes and substrates come together (lock and key or educed fit)
    - Act on specific substrates- the reactants that bind to the enzyme
    - Catalyst- lowers activation energy and speeds up chemical reactions
    - Active site- the enzyme fits into an area that fits its shape on the substrate
    - When the substrate fits the active site, it causes the enzyme to alter its shape
    - After the reaction, the enzyme is releases and it goes back to its original shape
    - It can go on to carry out the same reaction again and again
    - The enzyme is not altered after a chemical reaction
    - Disruptions in homeostasis can prevent enzymes from functioning
    - Enzymes function best in a small range of conditions
      - Changes in temperature can break hydrogen bonds
      - Function depend on structure
    - Buffers- mixtures that can react with acids and bases to keep the pH within a particular range

- **Properties of water**
  - Makes up 70-95% of most organisms
  - Serves as a mean of transportation for materials in organisms
  - Water is Polar-a molecule with an unequal distribution of charge; each molecule has a positive end and a negative end
    - This occurs when two atoms form covalent bonds, they do not share electrons equally
  - Shared electrons are attracted by the oxygen atom more strongly than by the hydrogen atoms
    - Therefore the electrons spend more time near the oxygen atom
  - Since water is polar it attracts other polar molecules and other water molecules
  - The positively charged hydrogen atoms of one water molecules are attracted to the negatively charged oxygen atoms
    - Has the ability to creep up tubes because it is polar(plants)

- Water requires more heat to increase temperature than other substances
- Water loses a lot of hear when it cools
- Therefore it is a good insulator and maintains a steady environment when conditions change
- Water expands when it freezes
  - Because of this property ice is less dense than water and it floats.

- **Carbon: how many bonds it can form, types of bonds**
  - Has 4 electrons available for bonding in its outer energy level
  - In order to become stable, it forms 4 covalent bonds to fill its energy level
  - Carbon can bond with other elements or with other carbon molecules
  - When each atoms shares one pair of electrons a single bong forms
  - When each atom shares two pairs of electrons a double bond forms
  - When each atom shares three pairs of electrons a triple bond forms
  - When they bond to each other they can form:
    - Straight chains
    - Branched chains
    - Rings

- **Isomers: Glucose and fructose**
  - Compounds that have the same simple formula but different three dimensional structures

- **Monomers and polymers**
  - Monomers-A molecule that can combine with others to form a polymer.
  - Polymers(macromolecules)-large molecules formed when many smaller molecules bond together
    - Organized into four major groups:
      - Carbohydrates
      - Lipids
      - Proteins
      - Nucleic acids

- **Condensation and hydrolysis reactions**
  - Condensation reactions(dehydration synthesis)- chemical reactions that make up polymers
    - Water is removed as a by product
  - Hydrolysis reactions-chemical reactions that break polymers
    - Water is put into the reaction

- **Fatty acids**
  - The building blocks for lipids

- **Amino acid**
  - Building blocks for proteins

- **Monosaccharide, disaccharides, polysaccharides**

- Monosaccharide- building block for carbohydrates
- Disaccharides- two monosaccharides that bond together
- Polysaccharides- the largest carbohydrates; polymers made of many monosaccharides

- **Organic molecules: carbohydrates, lipids, proteins and nucleic acids**
  - Carbohydrates
    - Organic compound composed of carbon, hydrogen and oxygen
    - Used by cells to store and release SHORT TERM energy
    - Ex: glucose and fructose=sucrose
    - Made of monosaccharides
    - Polysaccharides-
      - Starch is used as food storage by plants
      - Mammals store food in their liver in the form of glycogen
      - Cellulose is in the cell wall of plants and gives structural support
  - Lipids
    - Organic compounds that have a large proportion of C-H bonds
    - Commonly called fats
    - Composed of fatty acids, glycerol, and other components
    - Insoluble in water because they are non polar
      - No net charge therefore, they are nor attracted to water
    - Cells use lipids:
      - Energy storage
      - Isolation
      - Protective coatings
      - Major component of cell membrane(plasma membrane)
    - Most common lipid: 3 fatty acids attached to a glycerol
    - Saturated fats have only single bonds
    - Unsaturated fats have at least one double bond.
    - Polysaturated- fats with more than one double bond
  - Proteins
    - Large complex polymer made of carbon, hydrogen, oxygen, nitrogen, and usually sulfur.
    - Provide structure for tissues and organs, carry out cell metabolism, aid in the transport of oxygen

    in the blood and carry out chemical reaction.
    - Enzymes are a type of protein
    - Basic building blocks are amino acids - there are 20 amino acids
    - Amino acids link together to form proteins through peptide bonds.
  - Nucleotides
    - Complex, macromolecule that stores cellular information in the form of a code
    - Nucleotide- polymers made of small subunits
    - Consist of carbon, hydrogen, oxygen, nitrogen, and phosphorus
    - Arranged in three groups:

        - Nitrogen base
        - Sugar
        - Phosphate group
    - Ex: DNA (deoxyribonucleic acid)
        - Info in DNA contains all the instructions for making proteins
        - Determines how an organism looks and acts
        - Passed on from generation to generation
    - Ex: RNA(ribonucleic acid)
        - Forms a copy of DNA for use in making proteins
- **Be able to identify the organic structures of organic molecules**
    - Wksht
- **Know what elements make up each organic molecule**
    - **Carbohydrates - Carbon, hydrogen, and oxygen**
    - **Lipids - Carbon and Hydrogen**
    - **Proteins - Carbon, oxygen, nitrogen, and usually sulfur**
    - **Nucleic Acids - carbon, hydrogen, oxygen, nitrogen, and phosphorus**

Parts of the Cell/Cell Membrane/Transport into and out of the Cell Unit

Chapter 7

- Vocabulary - See notes/ vocab sheet
- Notes, HW, Labs, Textbook
- Scientists who helped develop the cell theory
    - Hooke - coined the term cells - looks like a room that monks live in
    - Leeuenhoek - first person to use the microscope (looked at water)
    - Schleiden - said that all plants are composed of cells
    - Schwann - conclusion that all animals were made of cells. All living things are made of cells.
    - Virchow - cells have to come from pre-existing cells
- Cell theory: 3 parts
    1. All living organisms are composed of one or more cells.
    2. Cells are the basic unit of structure and organization of all living organisms.
    3. Cells arise only from previously existing cells, with cells passing copies of their genetic material on to their daughter cells.
- Differences between prokaryotic and eukaryotic cells.

Eukaryotic cells

Complex Structure
Membrane bound organelles
Nucleus
Single or multi-cellular

Prokaryotic cells

Simple Structure
No nucleus
No membrane bound organelles
No internal structure
Small - ex. bacteria

Both

Plasma (Cell Membrane)
Microscopic
Cytoplasm

- Organelles (their functions, what they look like, what kinds of cells they are in, etc..): mitochondria, chloroplast, nucleus, nucleolus, ribosomes, smooth and rough endoplasmic reticulum, golgi apparatus, flagella, cilia, cytoplasm, centrioles, centrosomes, cell wall, vesicles, vacuoles, lysosomes, cytoskeleton, nuclear pore
- **P. 193 text**

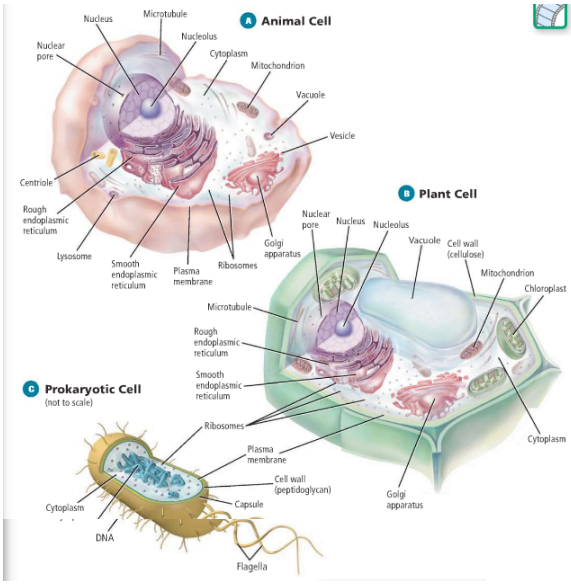
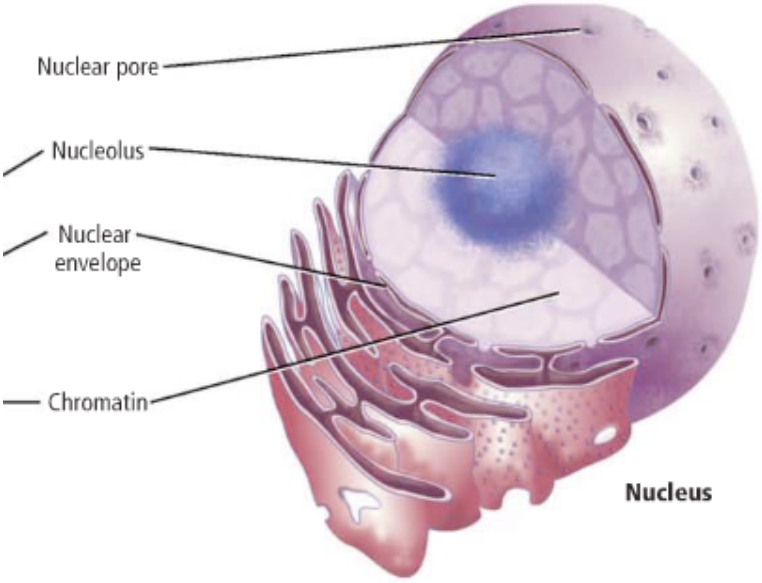


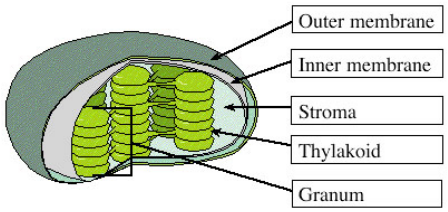
Table 7.1 Summary of Cell Structures

Cell Structure	Example	Function	Cell Type
Cell wall		An inflexible barrier that provides support and protects the plant cell	Plant cells, fungi cells, and some prokaryotes
Centrioles		Organelles that occur in pairs and are important for cell division	Animal cells and most protist cells
Chloroplast		A double-membrane organelle with thylakoids containing chlorophyll where photosynthesis takes place	Plant cells only
Cilia		Projections from cell surfaces that aid in locomotion and feeding; also used to sweep substances along surfaces	Some animal cells, protist cells, and prokaryotes
Cytoskeleton		A framework for the cell within the cytoplasm	All eukaryotic cells
Endoplasmic reticulum		A highly folded membrane that is the site of protein synthesis	All eukaryotic cells
Flagella		Projections that aid in locomotion and feeding	Some animal cells, prokaryotes, and some plant cells
Golgi apparatus		A flattened stack of tubular membranes that modifies proteins and packages them for distribution outside the cell	All eukaryotic cells
Lysosome		A vesicle that contains digestive enzymes for the breakdown of excess or worn-out cellular substances	Animal cells only
Mitochondrion		A membrane-bound organelle that makes energy available to the rest of the cell	All eukaryotic cells
Nucleus		Control center of the cell that contains coded directions for the production of proteins and cell division	All eukaryotic cells
Plasma membrane		A flexible boundary that controls the movement of substances into and out of the cell	All eukaryotic cells
Ribosome		Organelle that is the site of protein synthesis	All cells
Vacuole		A membrane-bound vesicle for the temporary storage of materials	Plant cells–one large; animal cells–a few small



Within the nucleus is the site of ribosome production called the nucleolus. - Found in all cells
Nuclear Pores - allow the movement of substances through it, it allows RNA to leave the nucleus - Found in all cells
Centrosomes - produce microtubules - found in plant and animal cells near the nucleus (round shape)
Vesicles - build lysosomes, pack in large molecules from golgi, transport large objects throughout the cell - Found in all Eukaryotic cells (Small blister like structures)

- Parts of the chloroplast:



  - Stroma - liquid in cholorplast
  - Grana - stack of disks
  - Thylakoid - disk-shaped compartments, where energy from sun is trapped by chlorophyll
- Mitochondria:
  - highly folded inner membrane – why is it there? - provides larger surface area and energy that is stored (through cellular respiration)
- Where cellular respiration occurs? - Mitochondria
- Where photosynthesis occurs? - Chloroplasts
- Differences between plant and animal cells. - Both have a nucleus
  - Plant cells have a rectangular/ square shape, a cell wall, and chloroplasts
  - Animal cells have a circular shape and no cell wall

Structure/Organelle	Animal Cells	Plants Cells
Cell Wall		✔
Centrioles	✔	
Chloroplast		✔
Cilia	✔	
Cytoskeleton	✔	✔
Endoplasmic Reticulum	✔	✔
Flagella	✔	✔
Golgi Apparatus	✔	✔
Lysosome	✔	
Mitochondrion	✔	✔
Nucleus	✔	✔
Plasma Membrane	✔	✔
Ribosome	✔	✔
Vacuole	✔ (Small)	✔ (Large)

- Describe the structure of the cell/plasma membrane. (helps control what enters and leaves the cell)
    - 2 layers of phosolipids (bilayer) that mirror each other
    - Cholesterol - keeps it stable, prevents fatty acids from sticking together
    - Transport Proteins - move needed substances or waste materials through the plasma membrane, contributing to the selective permeability of the plasma membrane.
        - Why do some molecules pass through a membrane protein? (See above)
- Carbohydrate Chains - send signals in and out of cell Phospholipids:
    - polar head - facing watery environments that are inside and outside of the cell
    - non-polar tail - inside
    - hydrophilic head - water loving
    - hydrophobic tails - Repelling, tending not to combine with, or incapable of dissolving in water.
- Why are phospholipids arranged as mirror images of each other in the cell membrane? - So that the polar heads can be closest to the water molecules and the nonpolar tails can be farthest away from the water molecules
- Summarize how chemical signals are transmitted across the cell membrane.-**Carbohydrate chains**
- Fluid mosaic model (plasma membrane model) - the phospholipids create a "sea" in which other molecules can float. This "Sea" concept is the basis for the model.
- Selective permeability - a key property of the plasma membrane by which a membrane allow some substances to pass through while keeping others out.
- How many layers are there in the plasma/cell membrane? - **2**

- Concentration gradient - difference in concentration across a space

- Active transport: against the concentration gradient (low to high); requires energy (ATP)
- Passive transport: with the concentration gradient (high to low), not using energy

- Describe passive transport. - movement of particles across the cell membrane **without using energy.**
    - Distinguish between three types of passive transport: simple diffusion, facilitated diffusion and osmosis.
        - Simple diffusion - the net movement of particles from an area of higher concentration to an area of lower concentration. (Controlled by temp, press., and concentration)
            - Dynamic equilibrium is reached when the diffusion of material into the cell equals the diffusion of material out of the cell
        - Facilitated diffusion - movement of materials across the membrane using proteins
    - Osmosis - diffusion of water across a selectively-permeable membrane
    - Solutions:
        - **Isotonic -** water and dissolved substances diffuse into and out of the cell at the same rate

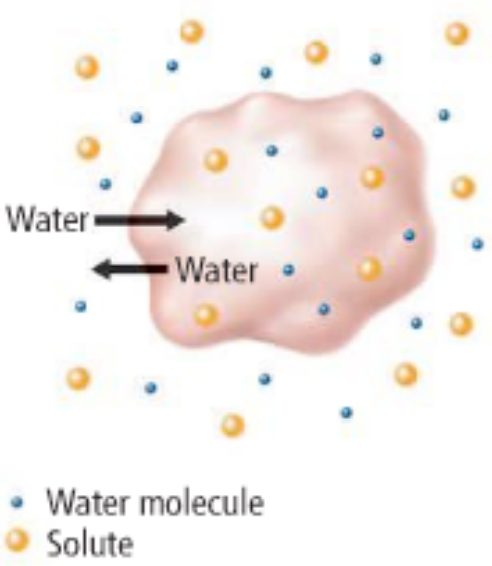


Figure 7.23 In an isotonic solution, water molecules move into and out of the cell at the same rate, and cells retain their normal shape. The animal cell and the plant cell have their normal shape in an isotonic solution.

        - **Hypotonic -** solute concentration is higher inside the cell, water diffuses into the cell

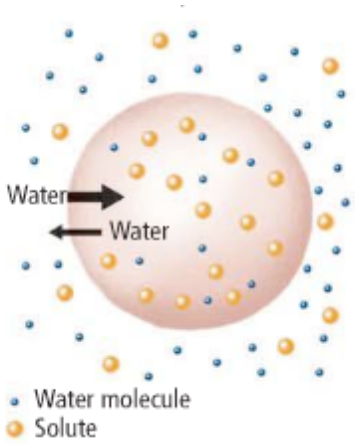


Figure 7.24 In a hypotonic solution, water enters a cell by osmosis, causing the cell to swell. Animal cells may continue to swell until they burst. Plant cells swell beyond their normal size as internal pressure increases.

- **Hypertonic -** solute concentration is higher outside the cell, water diffuses out of the cell

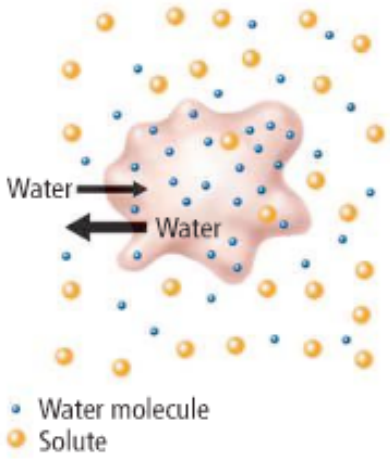


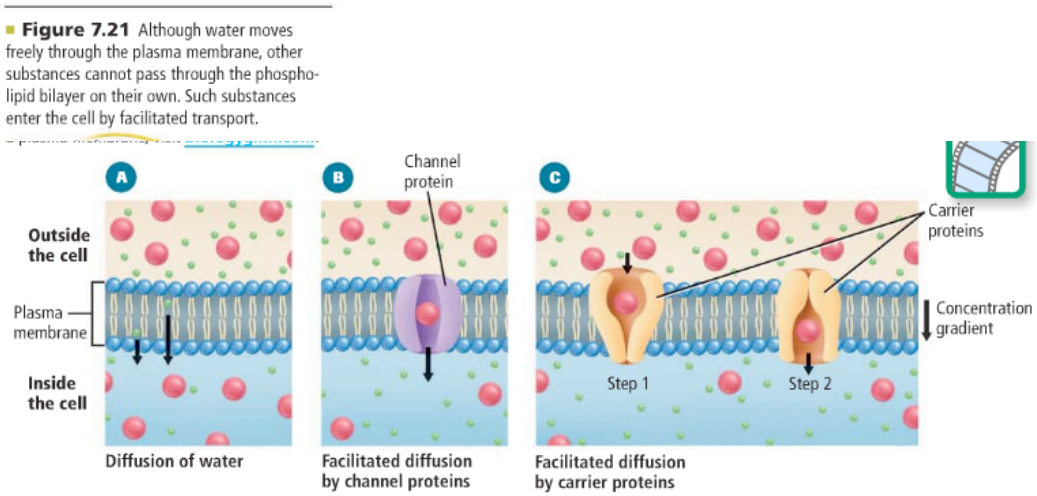
Figure 7.25 In a hypertonic solution, water leaves a cell by osmosis, causing the cell to shrink. Animal cells shrivel up as they lose water. As plant cells lose internal pressure, the plasma membrane shrinks away from the cell wall.

- What happens to a cell (animal and plant) in each of those solutions?
  - Isotonic - normal shape
  - Hypotonic - animal: may swell until it bursts plant: swell beyond normal size as press. increases.
  - Hypertonic - animal: shrivel up as they lose water plant: as lose int. press., the plasma membrane shrinks away from the cell wall

- Describe active transport. - the movement of particles from low concentration to high concentration, which is against the concentration gradient, using transport proteins
  - Distinguish between endocytosis and exocytosis.
    - Endocytosis - process by which the cell surrounds and takes particles **<u>into</u>** the cell
    - Exocytosis - secretion of material **<u>out</u>** of the plasma membrane
- Different types of endocytosis:
  - Phagocytosis - engulfing of large or small molecules by sudopods (fake feet)

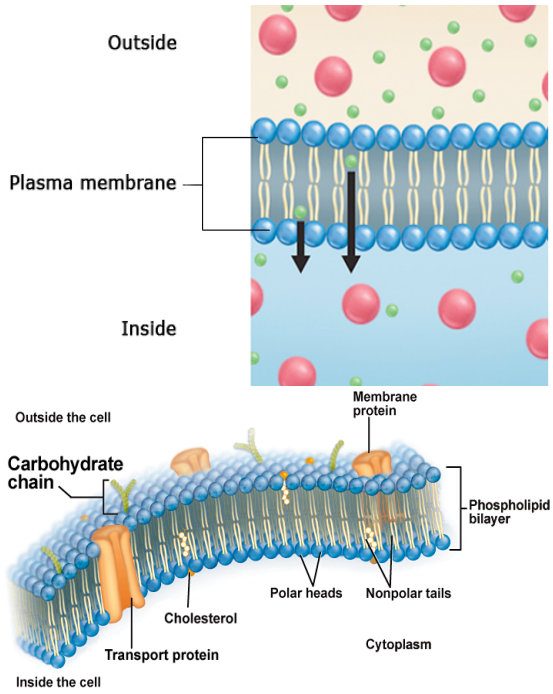
- Pinocytosis - cell drinking: uptake of large molecules (some type of liquid)
- Receptor mediated endocytosis - takes up large quantities of specific substances - takes extracelluar substance into cell.

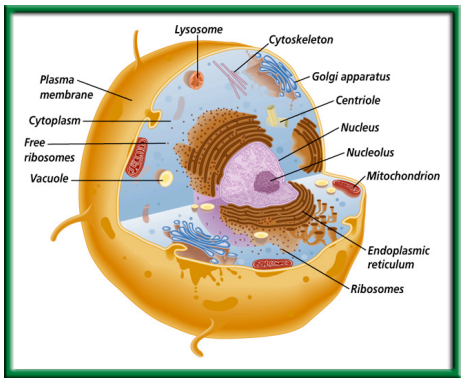
- How are endocytosis and exocytosis different than regular active transport? How are they different from diffusion? - Used when the substances are too large to move by diffusion or transport proteins
- Transport proteins:



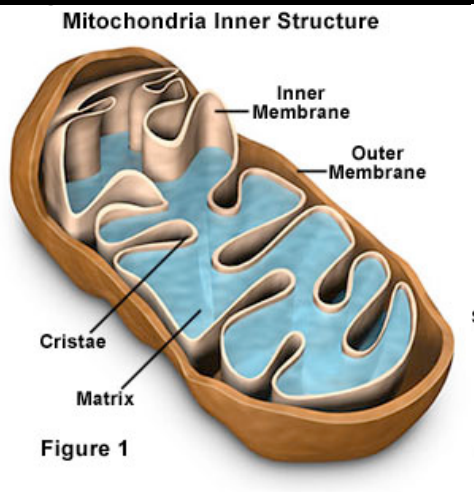
- carrier - change shape as the diffusion process continues to help move the particle through the membrane
- channel - opens and closes to allow the substance to diffuse through the plasma membrane

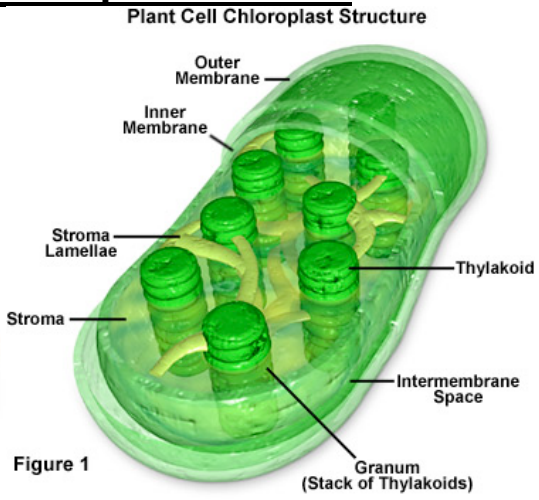
- How are pumps different from channels? - Pumps are enzymes that catalyze the breakdown of an energy-storing molecule. The Na^+/K^+ ATPase pump (sodium potassium) moves three Na out of the cells and two K into the cell. The high level of sodium creates a concentration gradient.





Photosynthesis and Cellular Respiration Unit





- Chapter 8
- All vocabulary – See Notes
- Energy: ATP, ADP, AMP; ATP cycle

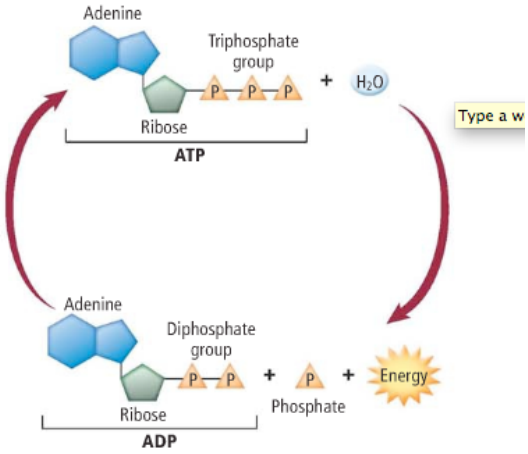


Figure 8.4 The breakdown of ATP releases energy for powering cellular activities in organisms.

- **<u>ATP: Adenosine Triposphate</u>** - the most important biological molecule that provides chemical energy.
- **<u>ADP: Adenosine Diphosphate</u>** – a molecule formed when, ATP releases energy when the bond between the second and third phosphate groups is broken forming a molecule (ADP) and a free phosphate group. **Energy is stored in the phosphate bond formed when ADP receives a phosphate group and becomes ATP.** ATP and ADP can be interchanged by the addition or removal of a phosphate group.
  - Sometimes ADP becomes Adenosine Monophosphate (AMP) by losing an additional phosphate group.
- **<u>AMP: Adenosine Monophosphate</u>** – sometimes ADP becomes this by losing an additional phosphate group. **There is less energy released in this reaction, so most of the energy reactions in the cell involve ATP and ADP.**

- *Describe how ATP works
  - ATP releases energy when the bond between the second and third phosphate groups is broken, forming a molecule called adenosine diphosphate (**ADP**) and a free phosphate group
- Thermodynamics: the two laws
  - **<u>Thermodynamics</u>** - the study of the flow and transformation of energy in the universe.
    - **The first law of thermodynamics** is the law of conservation energy, which states that energy can be converted from one form to another, but it cannot be created nor destroyed.
      - For example, the stored energy in food is converted to chemical energy when you eat and to mechanical energy when you run or kick a ball.
    - **The second law of thermodynamics** states that energy cannot be converted without the loss of usable energy.

- The energy that is "lost" is generally converted to thermal energy. Entropy is the measure of disorder, or unusable energy, in a system. Therefore, the second law of thermodynamics can also be stated "entropy increases." One example of the 2nd law is evident in food chains.

- Compare and contrast heterotrophs and autotrophs.
  - **Autotrophs** are organisms that make their own food.
  - **Heterotrophs** are organisms that need to ingest food to obtain energy.
- Metabolism - all of the chemical reactions in a cell.
  - A series of chemical reactions in which the product of one reaction is the substrate for the next reaction is called a metabolic pathway. Metabolic pathways include two broad types: catabolic and anabolic pathways.
- Definition of anabolic and catabolic reactions and ATP synthase
  - **Catabolic pathways** release energy by breaking down larger molecules into smaller molecule.
  - **Anabolic pathways** use the energy released by catabolic pathways to build larger molecules from smaller molecules
- Ultimate source of energy – **Sunlight**

- **Compare and contrast photosynthetic and chemosynthetic organisms**

○ **Photosynthetic**	○ **Chemosynthetic**
<u>Light</u> energy form the sun is converted to chemical energy for use by the cell. Used by plants Uses sunlight as energy via photosynthesis. This energy is made into glucose, which is eventually converted into ATP after many cycles. This ATP is a ready source of energy for the plant.	**<u>Chemical</u>** energy is used to build carbon-based molecules. • Some organisms don't need sunlight and photosynthesis as a source of energy and live in places that never get sunlight.
Both	
Types of Cell Energy - **Together they fuel all life on earth**	

-
- Photosynthesis:
  - Equation

$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

  - Steps
    - **Phase One: Light Dependent Reactions**
      - **Captures and transfers energy**
      - Takes place in thylakoids

- Water and sunlight is needed – captures energy from sunlight (carbon dioxide and chloroplasts are also needed)
- Chlorphyll absorbs energy
- Energy is transferred along the thylakoid membrane then to light-independent reactions
- Oxygen is released
- The light-dependent reactions include groups of molecules called photosystems.
- **Electron Transport**
    - Light energy excites electrons in photosystem II and also causes a water molecule to split – **photolysis.** This releases an electron into the electron transport system, H+ into the thylakoid space, and O2 as a waste product. **Releases electrons in electron transport chain.**
        - The excited electrons move from **photosystem II to** an electron-acceptor molecule in the thylakoid membrane.
    - The electron-acceptor molecule transfers the electrons along a series of electron-carriers to **photosystem I – another electron trans. chain**
        - Photosystem I transfers the electrons to a protein called ferrodoxin.
        - Ferrodoxin transfers the electrons to the electron carrier NADP+, forming the energy-storing molecule NADPH.

- **Phase Two: Light Independent Reactions (Calvin Cycle)**
    - **Uses energy from the first stage to make sugar**
    - In Stroma
    - In the second phase of photosynthesis, called the Calvin cycle, energy is stored in organic molecules such as glucose.
    - Six CO2 molecules combine with six 5-carbon compounds to form twelve 3-carbon molecules called 3-PGA.
    - The chemical energy stored in ATP and NADPH is transferred to the 3-PGA molecules to form high-energy molecules called G3P.
    - Two G3P molecules leave the cycle to be used for the production of glucose and other organic compounds.
    - An enzyme called **rubisco** converts the remaining ten G3P molecules into 5-carbon molecules called RuBP.

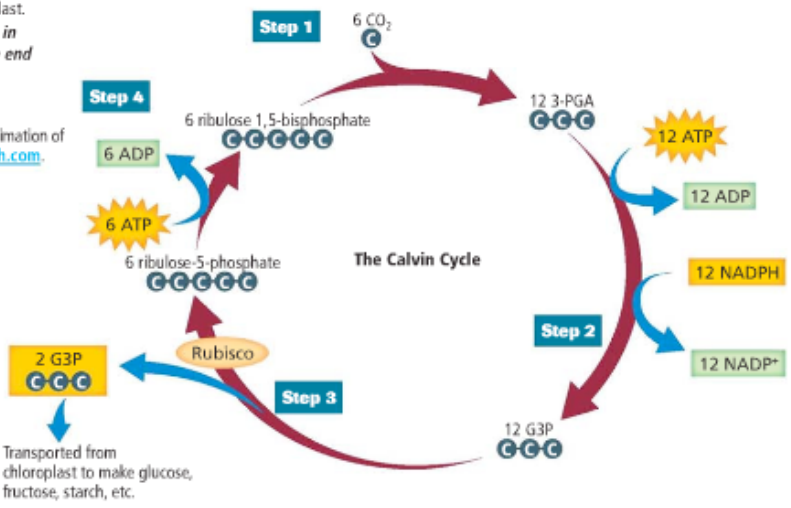
- Why is it important?
    - **Purpose of Photosynthesis = to convert sunlight energy to chemical energy.**
    - Life is powered by sunlight. The energy used by most living cells comes ultimately from the sun. Plants, algae, and some bacteria use energy

from sunlight, particularly blue and red wavelengths, to build molecules which later can be split through cellular respiration to retrieve some of that energy. Storing energy in molecules and then oxidizing those molecules to retrieve the stored energy maintains all life on Earth. Plants are often called 'producers' because they produce energy-storing molecules used by almost all other organisms on Earth. By eating plants, herbivores 'steal' these energy-storing molecules to maintain their own life processes. By eating animals, carnivores 'plunder' the molecules that store the energy oringinally captured by plants. By feeding on dead tissue, decomposers exploit whatever molecules remain in the dead the plants, herbivores, and carnivores. Ultimately, the process of photosynthesis is the most important chemical reaction on Earth. As biologists are well aware, "Roses are red, violets are blue. If the green plants go, then so do you!"

- **Summarize the two phases of photosynthesis:**
  - light dependent - **light energy is absorbed and then converted into chemical energy in the form of ATP an NADPH.**
  - light independent (Calvin Cycle) -**energy is stored in molecules such as glucose – makes sugar.** the ATP, and NADPH that were formed in phase one are used to make glucose. Once glucose is produced, it can be joined to other simple sugars to form larger molecules. These molecules are complex carbohydrates, such as starch. The end products of photosynthesis also can be used to make other organic molecules such as proteins, lipids and nucleic acids.
- Calvin cycle:

structural support for the plant.

Figure 8.9 The Calvin cycle joins carbon dioxide with organic molecules inside the stroma of the chloroplast.
Determine *the compound in which energy is stored at the end of the Calvin cycle.*
Concepts in Motion
Interactive Figure To see an animation of the Calvin cycle, visit biologygmh.com.



  - where does it take place? - **Stroma**
  - what is another name for the Calvin cycle? - **light independent reactions**
  - what are the main steps?

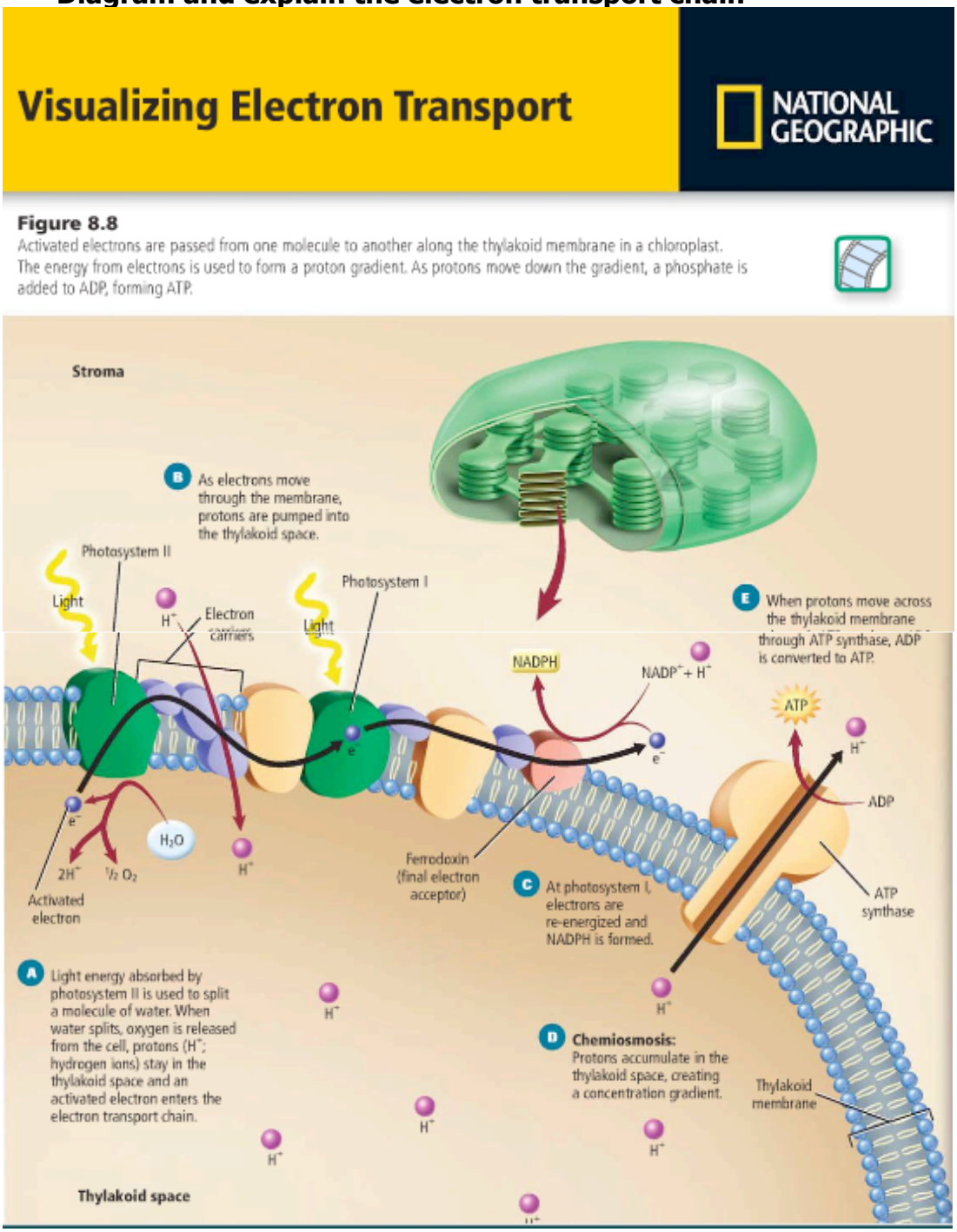
- **In the second phase of photosynthesis, called the Calvin cycle, energy is stored in organic molecules such as glucose.**
- **Six CO2 molecules combine with six 5-carbon compounds to form twelve 3-carbon molecules called 3-PGA.**
- **The chemical energy stored in ATP and NADPH is transferred to the 3-PGA molecules to form high-energy molecules called G3P.**
- **Two G3P molecules leave the cycle to be used for the production of glucose and other organic compounds.**

▪

- When is glucose formed in photosynthesis? – **After/ end of calvin cycle w/ oxygen**
- Photolysis – **The splitting of water with hydrogen and oxygen ions – during phase 1.**
- Rubisco and its role in the Calvin cycle - **an enzyme that converts** the remaining ten G3P molecules into 5- carbon molecules called ribulose 1, 5-biphosphates (RuBP). These molecules combine with new carbon dioxide molecules to continue the cycle. The final step of the Calvin cycle
- Where does each phase of photosynthesis occur?
  - Phase 1 – Chloroplasts – **Thylakoids (Chlorophyll)**
  - Phase 2 - **Stroma**

- Structure of Chloroplast:
  - **Thylakoid** - flattened saclike membranes that are arranged in stacks. One of the main compartments essential to photosynthesis. (**Phase 1)**
  - **Grana** - the stacks of thylakoids
  - **Stroma** - the fluid compartment that is outside the grana. This is the location of the light-independent reactions in **phase two** of photosynthesis. One of the main compartments essential to photosynthesis.
  - **Chlorophyll** – the major pigments in plants. It absorbs most wavelengths of light except green.
- The role of glucose in photosynthesis and cellular respiration – **product of photosynthesis and reactant for cellular respiration**
- Explain the function of the chloroplast during the light reactions – **capture light energy in photosynthetic organisms.**

- ***Diagram and explain the electron transport chain



-
  - **Photosystem II - When water molecules split, two electrons are released as a waste product (photolysis) , releases electrons in electron transport chain**
  - **Photosytem I – another electron transport chain (bucket brigade)**
- Pigments:
  - **absorption spectrum**

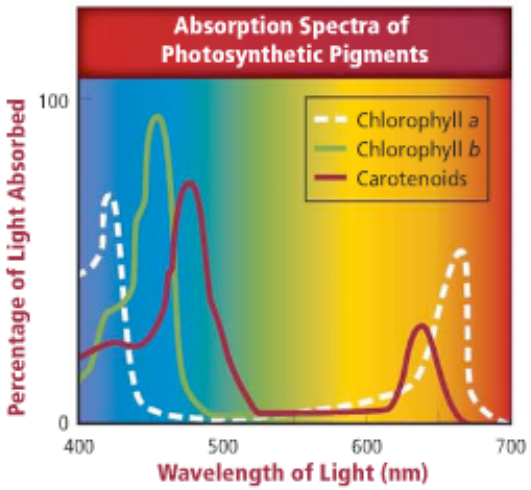


Figure 8.6 Colorful pigments found in the leaves of trees differ in their ability to absorb specific wavelengths of light.

- reflection – **green region of spectrum, why plant pars that have chlorophyll appear green to the human eye.**
- ROYGBIV – **Visible light spectrum**
- chlorophyll a and b – **there are two types of chlorophyll. A absorbs darker colors. B absorbs lighter colors.**

- What are some of the alternatives to photosynthesis? - **C4 and CAM**
- What do C4 and CAM plants do?
  - C4 – **fix carbon dioxide in to 4-carbon compound instead of 3 carbons compounds like the cycle. Minimizes water loss, keep stomata (Pores) closes. Ex – sugar cane, corn.**
  - CAM – **CO_2 enters the leaves only at night when it is cooler and more humid during the day CO_2, enters the Calvin Cycle. Occurs in water conserving plants. Ex – cactus, orchids, pineapple.**
- Cellular Respiration:
  - Equation

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

  - why is it necessary? - **The function of cellular respiration is to harvest electrons from carbon compounds, such as glucose and use that energy to make ATP. ATP is used to provide energy for cells to do work.**

- Cellular respiration steps:

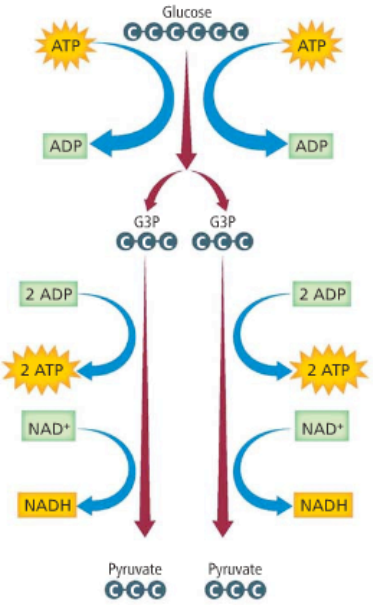
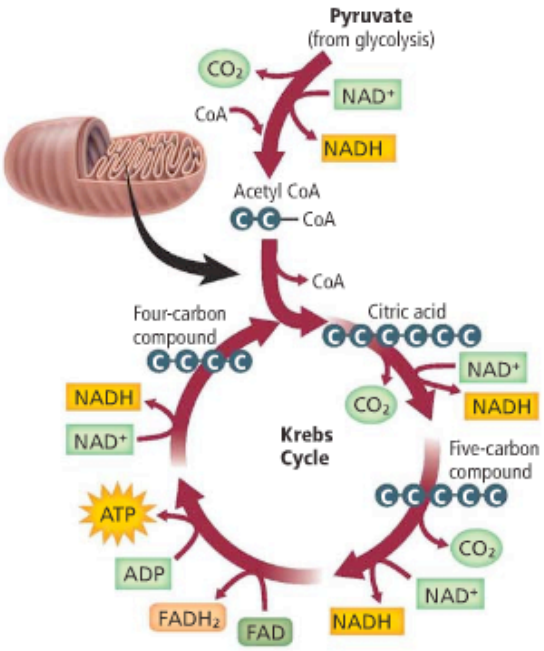


Figure 8.12 Glucose is broken down during glycolysis inside the cytoplasm of cells.
Summarize *the reactants and products of glycolysis.*

- Glycolysis - **the process when glucose is broken down in the cytoplasm**

Figure 8.13 Pyruvate is broken down into carbon dioxide during the Krebs cycle inside the mitochondria of cells.
Trace *Follow the path of carbon molecules that enter and leave the Krebs cycle.*

Concepts In Motion
Interactive Figure To see an animation of the Krebs cycle, visit biologygmh.com.



- Krebs cycle (citric acid cycle) - **(or tricarboxylic acid (TCA) cycle) series of reactions in which pyruvate is broken down into carbon dioxide.**

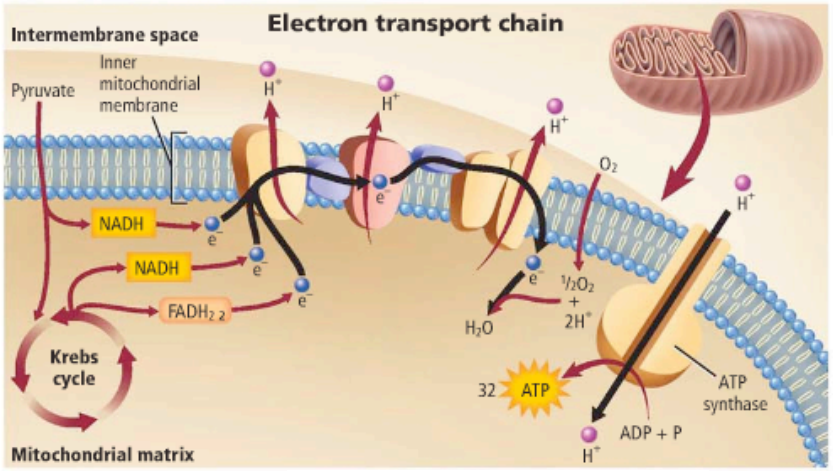


Figure 8.14 Electron transport occurs along the mitochondrial membrane.

- electron transport chain

- Where does each step in cellular respiration occur?
  - Glycolysis – **in cytoplasm <u>ANAEROBIC</u>**
  - krebs cycle (citric acid cycle) – **in mitochondria - <u>AEROBIC</u>**
  - electron transport chain – **along mitochondrial membrane <u>AEROBIC</u>**
- What is the final electron acceptor in the electron transport chain of cellular respiration? **- Oxygen**
- NADP+/NADPH – what is the role of these electron carriers?
- ***Compare and contrast photosynthesis and cellular respiration.**

Photosynthesis	**Cellular Respiration**
• Produces glucose and oxygen • Only plant cells • Requires sunlight • Requires chloroplasts and chlorophyll • Requires Carbon Dioxide and water • Carbon dioxide taken in, (oxygen out)	• Produces CO_2 and Water • Animal and plant cells • Requires mitochondria, oxygen and glucose • Breaks down glucose – energy released • Doesn't require sunlight • Oxygen taken in, (Carbon Dioxide out) The process by which mitochondria break down food molecules to produce ATP organisms
Both	
Important processes that cells use to obtain energy	

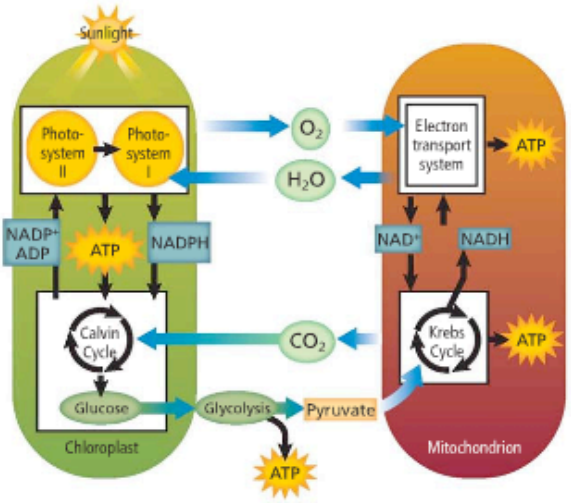
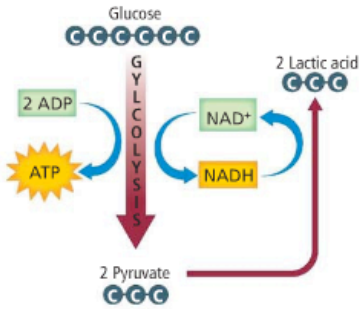
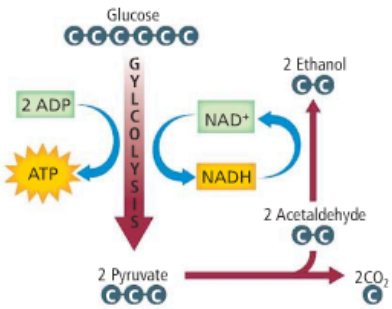


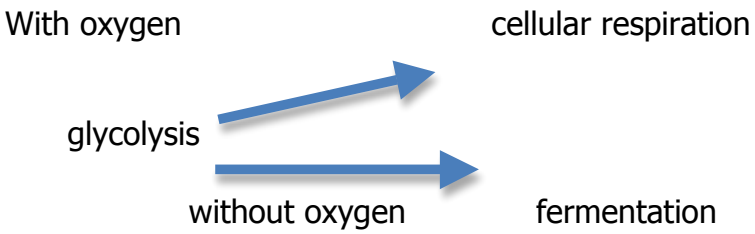
Figure 8.16 Photosynthesis and cellular respiration form a cycle in which the products of one metabolic pathway form the reactants of the other metabolic pathway.

Photosynthesis and Cellular Respiration

As you have learned, photosynthesis and cellular respiration are two important processes that cells use to obtain energy. They are metabolic pathways that produce and break down simple carbohydrates. **Figure 8.16** shows how these two processes are related. Recall that the products of photosynthesis are oxygen and glucose—the reactants needed for cellular respiration. The products of cellular respiration—carbon dioxide and water—are the reactants for photosynthesis.

- How many ATPs are formed in cellular respiration? **36**
- What about fermentation? **2 ATP**
- What does net gain mean? **- overall gain including what left cell**
- Anaerobic/aerobic processes
  - Anaerobic – **no oxygen is required**
  - Aerobic – **require oxygen**
- **Fermentation: lactic acid/alcoholic – compare and contrast**

○ **Lactic Acid**	○ **Alcoholic**
Lactic Acid Fermentation  	**Alcohol Fermentation** 
Enzymes convert the pyruvate made during glycolysis to lactic acid. This involves the transfer of high-energy	occurs in yeast and some bacteria. The picture above show the chemical reaction that occurs during alcohol fermentation

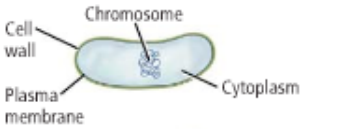
electrons and protons from NADH. Skeletal muscle produces lactic acid when the body cannot supply enough oxygen, such as during periods of strenuous exercise. When lactic acid builds up in muscle cells, muscles become fatigued and might feel sore. Lactic acid also is produced by several microorganism that often are used to produce many foods, including cheese, yogurt, and sour cream.	when pyruvate is converted to ethyl alcohol and carbon dioxide. Similar to lactic acid fermentation, NADH donates electrons during this reaction and NAD+ is regenerated.
Both	
Types of Fermentation – **an anaerobic process** - occurs when oxygen is not available for cellular respiration 	

- **Compare and contrast cellular respiration and fermentation**

○ **Cellular Respiration**	○ **Fermentation**
Oxygen – 36 ATP The process by which mitochondria break down food molecules to produce ATP organisms	2 ATP – Not enough Oxygen
Both	
Both Cell Processes	

Mitosis and Meiosis Unit

- Sections in the textbook: Chapter 9 and 10.1
- All vocabulary words – See Notes
- Binary fission and asexual reproduction
  - What is binary fission? – the asexual reproduction of a prokaryotic cell by division into two roughly equal parts (two daughter cells) genetically identical to the parent cell; uses less energy than mitosis.
  - Be able to diagram and explain binary fission.



Binary fission

Figure 18.6 Binary fission is an asexual form of reproduction used by some prokaryotes. Conjugation is a method of exchanging genetic material used by some prokaryotes.

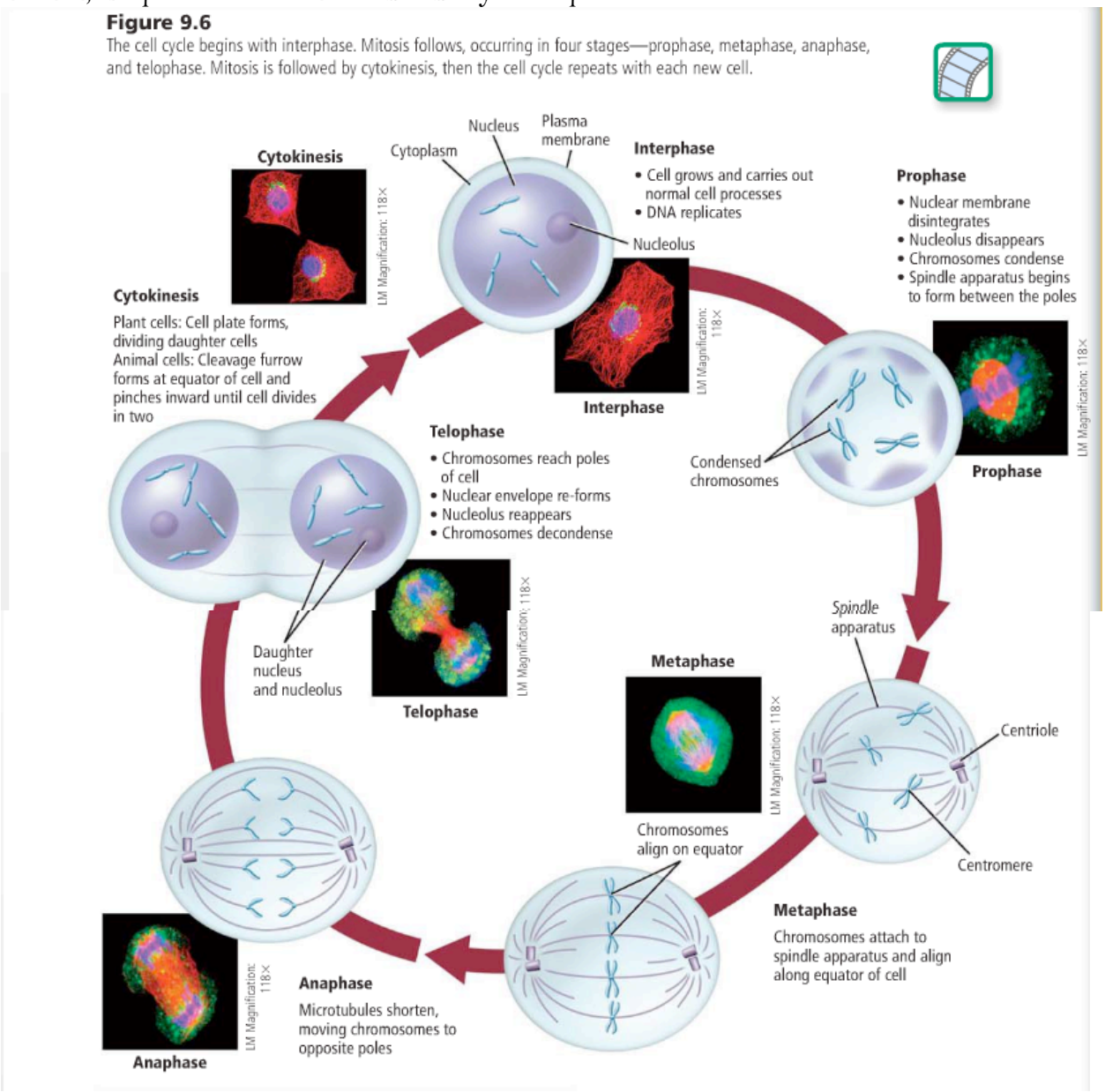
- What is the difference between asexual and sexual reproduction?
  - Asexual – the organism inherits all of its chromosomes from a single parent. Therefore, the new individual is genetically identical to its parent and any other offspring produced, barring any mutations. Bacteria reproduce asexually.
  - Sexual – the organism inherits half of its chromosomes from its father, and the other half from its mother.
  - Bacteria reproduce asexually, whereas most protists reproduce both asexually and sexually. Many plants and many of the more simple animals can reproduce both asexually and sexually, compared to more advanced animals that reproduce only sexually.
- What kind of cells go through binary fission? - Prokaryotes
- Binary fission and mitosis are both asexual – both produce daughter cells genetically identical to the parent cell. They are both asexual reproduction. Binary fission occurs in prokaryotes, while mitosis occurs in eukaryotes. Mitosis splits by binary fission. Binary fission uses less energy than mitosis.

- Why does a cell need to divide? – As a cell grows, it's volume increases faster than it's surface area – therefore cells might have a hard time moving nutrients into and out of the cell.
  - Surface Area to Volume Ratio – diffusion over large distances is slow; smaller cells function better
  - Reasons – communication is better in a small cell
- Identify the phases of mitosis and be able to describe the phases:
  - Prophase - the first stage of mitosis and the longest phase. In this stage, the cell's chromatin tightens, or condenses into chromosomes. In prophase, the chromosomes are shaped like an X as shown in the picture above. At this point, each chromosome is a single structure that contains the genetic material that was replicated in interphase.
  - Metaphase - the sister chromatids are pulled by motor proteins along the spindle apparatus toward the center of cell and line up in the middle, or equator of the cells. Mitosis is one of the shortest stages of mitosis, but when completed successfully, it ensures that the new cells have accurate copies of the chromosomes.

- Anaphase - the chromatids are pulled apart during the 3rd stage of mitosis. In anaphase, the microtubules of the spindle apparatus begin to shorten. This shortening pulls at the centromere of each sister chromatid, causing the sister chromatids to separate into two identical chromosomes. All of the sister chromatids separate simultaneously, although the exact mechanist that controls this is unknown. At the end of anaphase, the microtubules, with the help of motor proteins, move the chromosomes toward the poles of the cells.
- Telophase - the last stage of mitosis during which the chromosomes arrive at the poles of the cell and begin to relax or decondense. Two new nuclear membranes begin to form and the nucleoli reappear. The spindle apparatus disassembles and some of the microtubules are recycled by the cell to build various parts of the cytoskeleton. Although the four stages of mitosis are now complete and the nuclear material is divided, the process of cell division is not yet complete.

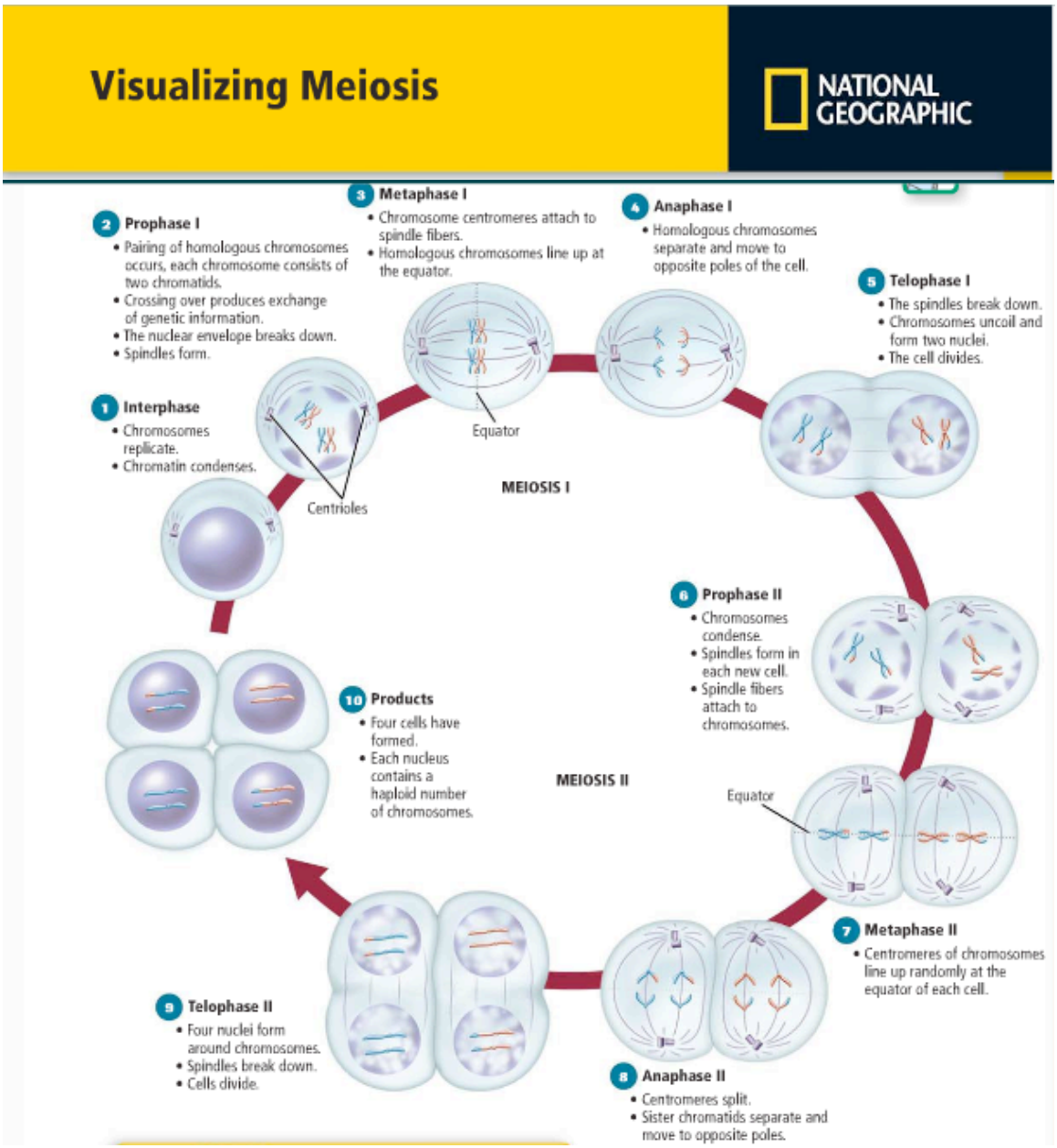
Figure 9.6

The cell cycle begins with interphase. Mitosis follows, occurring in four stages—prophase, metaphase, anaphase, and telophase. Mitosis is followed by cytokinesis, then the cell cycle repeats with each new cell.



- Identify the phases of meiosis and be able to describe the phases:

- Meiosis 1
  - Prophase 1 – (**Diploid cell**) chromosomes pair with their homologous chromosomes and form a tetrad. Crossing over also occurs.
  - Metaphase 1 - Homologous chromosomes line up in the middle of the cell. Spindle fibers attach to the chromosomes.
  - Anaphase 1 – Spindle fibers pull homologous chromosomes toward opposite ends of the cell.
  - Telophase 1(And Cytokinesis) – Nuclear membrane starting to reform. One cell begins to separate into 2 cells. Produces **two haploid cells.**
- Meiosis 2 (II)
  - Prophase 2 – (**2 haploid cells**.) Half of the number of chromosomes from the original cell.
  - Metaphase 2 – chromosomes line up in the center of the cell (similar to how they line up in mitosis).
  - Anaphase 2 – Sister chromatids separate. Move to opposite ends of the cell.
  - Telophase 2 (And Cytokinesis) – 4 haploid cells formed



- What is the difference between mitosis and meiosis?
  - Which one occurs in somatic cells? - Mitosis
  - Which one occurs to produce gametes? What are gametes? – Meiosis. Gametes are sex cells that have half the number of chromosomes. Although the number of chromosomes varies form one species to another, in humans each gamete contains 23 chromosomes. The symbol *n* can be used to represent the number of chromosomes in a gamete.
  - Know the difference between sperm and egg – spermatogenesis/oogenesis
    - Spermatogenesis: The formation of male gametes, they are haploid gametes called sperm, which are produced by meiosis.
    - Oogenesis: The formation of female gametes, mature eggs or ova. The cell divisions at the end of meiosis I and I are uneven – this happens that way the one cell that becomes the egg receives most of the cytoplasm. The other three

cells that are produced during oogensis are called **polar bodies** and they do not have a role in reproduction.

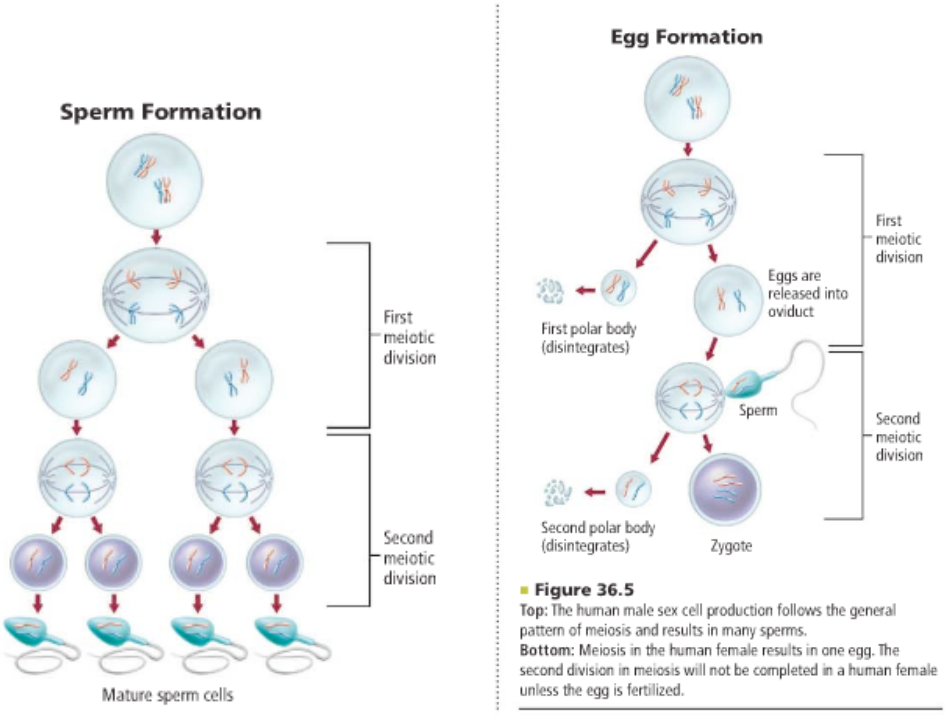
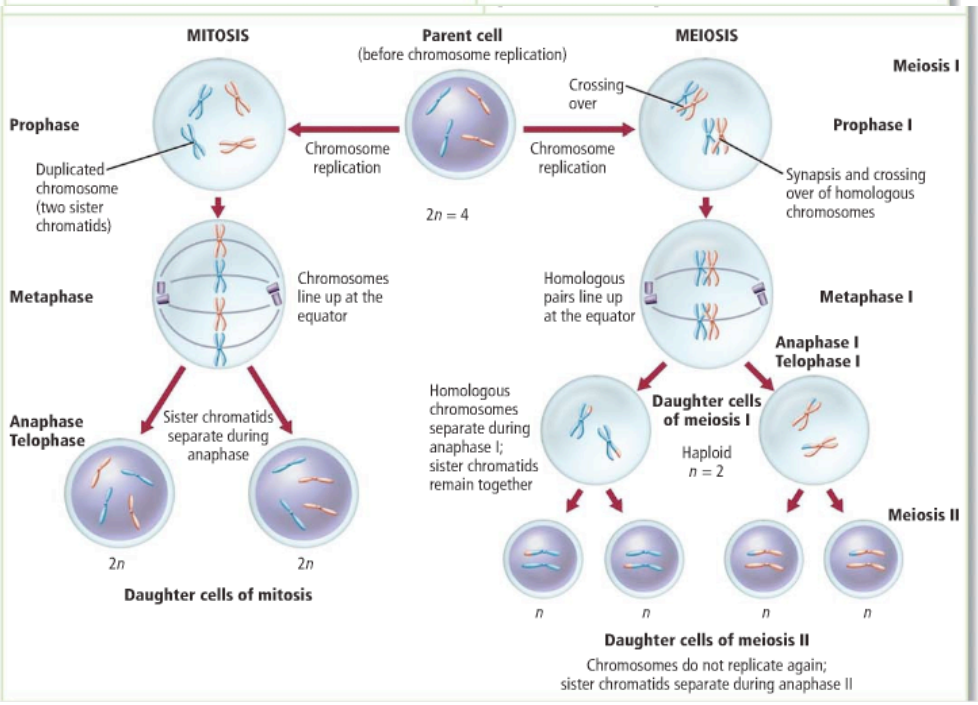


Figure 36.5
Top: The human male sex cell production follows the general pattern of meiosis and results in many sperms.
Bottom: Meiosis in the human female results in one egg. The second division in meiosis will not be completed in a human female unless the egg is fertilized.

Table 10.1 **Mitosis and Meiosis**

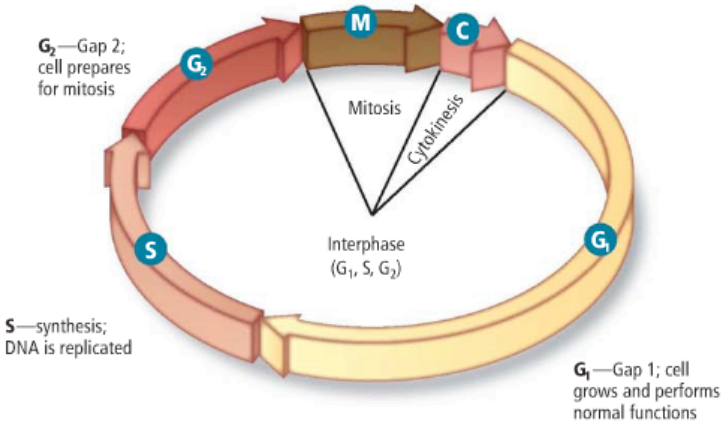
Interactive Table To explore more about mitosis and meiosis, visit biologygmh.com.

Mitosis	Meiosis
One division occurs during mitosis.	Two sets of divisions occur during meiosis: meiosis I and meiosis II.
DNA replication occurs during interphase.	DNA replication occurs once before meiosis I.
Synapsis of homologous chromosomes does not occur.	Synapsis of homologous chromosomes occurs during prophase I.
Two identical cells are formed per cell cycle.	Four haploid cells (n) are formed per cell cycle.
The daughter cells are genetically identical.	The daughter cells are not genetically identical because of crossing over.
Mitosis occurs only in body cells.	Meiosis occurs in reproductive cells.
Mitosis is involved in growth and repair.	Meiosis is involved in the production of gametes and providing genetic variation in organisms.

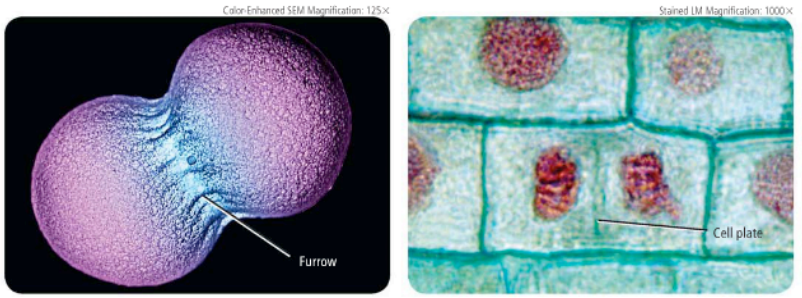


- What is a zygote? When does it form? – A fertilized egg formed in meiosis.

Figure 9.3 The cell cycle involves three stages—interphase, mitosis, and cytokinesis. Interphase is divided into three substages.
Hypothesize ***Why does cytokinesis represent the smallest amount of time a cell spends in the cell cycle?***



- Cell Cycle:
  - Interphase – made up of three parts; the stage during which the cell grows, carries out cellular functions, and replicates.
    - G1: Gap 1 – Cell spends a lot of time in this phase, growing occurs and cell caries out its functions
    - S: Synthesis – DNA replication (copy)
    - G2: Gap 2 – More replication
  - Mitosis – Division of nucleus and nuclear material Has 4 stages – prophase, metaphase, anaphase, and telophase.
  - Cytokinesis – cytoplasm divides, producing two new cells.



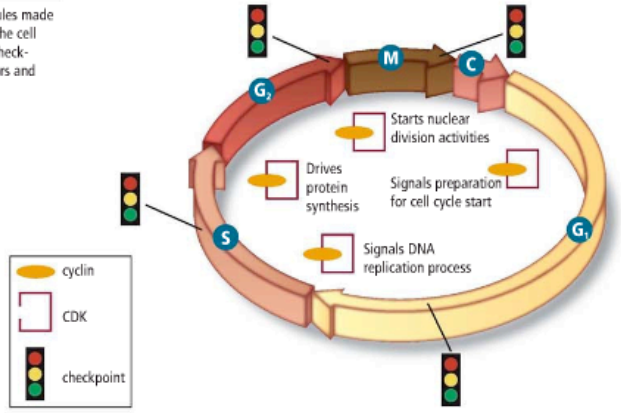
    - What is the difference between plant and animal cell cytokinesis
      - Animal cells – the cell membrane punches inward until there is a division of the cytoplasm of almost 2 equal parts.
      - Plant cells – a cell plate forms and it gradually develops into a separating membrane and the cell wall start to be seen in the cell plate.
    - What is G0? – Some cells that don't divide. They cannot be replaced (and you are born with them). Example – Brain cells
    - Do all cells go through the cell cycle at the same pace? – No

FIGURE 5.2 CELL DIVISION	
CELL TYPE	**APPROXIMATE LIFE SPAN**
Skin cell	2 weeks
Red blood cell	4 months
Liver cell	300–500 days
Intestine—internal lining	4–5 days
Intestine—muscle and other tissues	16 years

Figure 9.11 Signaling molecules made of a cyclin bound to a CDK kick off the cell cycle and drive it through mitosis. Checkpoints monitor the cell cycle for errors and can stop the cycle if an error occurs.

Personal Tutor

To learn about the cell cycle, visit biologygmh.com.

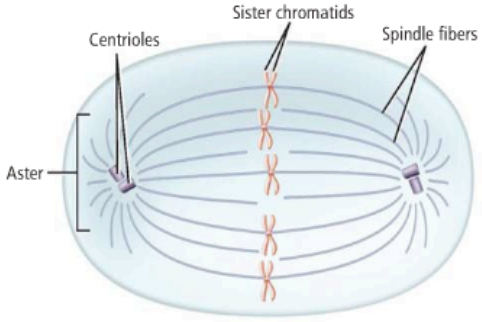


- Cell Cycle checkpoints: - has built in checkpoints that monitor the cycle and can stop it if something goes wrong.

Quality control checkpoints Recall the process of starting a car. Many manufacturers use a unique microchip in the key to ensure that only a specific key will start each car. This is a checkpoint against theft. The cell cycle also has built-in checkpoints that monitor the cycle and can stop it if something goes wrong. For example, a checkpoint near the end of the G_1 stage monitors for DNA damage and can stop the cycle before entering the S stage of interphase. There are other quality control checkpoints during the S stage and after DNA replication in the G_2 stage. Spindle checkpoints also have been identified in mitosis. If a failure of the spindle fibers is detected, the cycle can be stopped before cytokinesis. **Figure 9.11** shows the location of key checkpoints in the cell cycle.

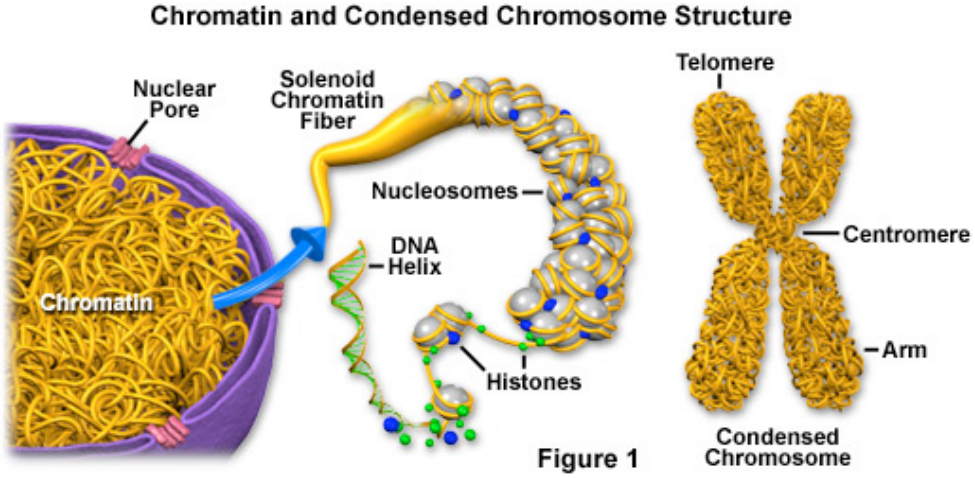
  - When do they occur? –
    - near the end of G1 – stage monitors for DNA damage and can stop the cycle before entering the S stage of interphase
    - During S
    - After DNA replication in the G2 stage
    - Mitosis
  - Why do they occur? – to stop it if something goes wrong
  - What happens during them? – see above
- What are telomeres? – at the end of chromosomes. They contain DNA that does not code for a gene.
- What are autosomes and sex chromosomes?
  - Autosomes: 44 autosomes, 22 pairs – Chromosomes numbers 1 to 22. **Aren't sex chromosomes.**
  - Sex Chromosomes: humans bond 2 sex chromosomes, x or y. Female- xx, Male - xy
- Centrioles: Two small structures in the cytoplasm that are bear the nuclear envelope, they separate and go to opposite pole or ends of the nucleus.
  - What types of cells do they occur in? – **Animal** and most protist cells
  - What is their association with asters? What are asters? – Centrioles migrate to the ends, or poles, of the cells. Coming out of the centrioles are yet another type of

microtubule called aster fibers, which have a star like appearance. Spindle Apparatus – the whole structure, including the spindle fivers, centrioles, and aster fibers.



- What are spindles? Where do they originate in plants and animals? – microtubule structure that helps to pull the chromosome apart. Spindle fibers form during prophase.

- Centromeres:
  - What are centromeres? - the structure at the center of the chromosome where the sister chromatids are attached. Where are they found? - center of the chromosome
  - What are they used for? - This structure is important because it ensures that a complete copy of the replicated DNA will become part of the daughter cells at the end of the cell cycle.
- Chromatin and Chromosomes:



  - What is the difference between the two?
    - Chromatin is the relaxed form of DNA in the cells nucleus (DNA plus protein (histones))
    - Chromosomes – Structures that contain the genetic material that is passed from generation to generation. (Condense at the beginning of mitosis. DNA wraps around proteins histones that condense it)
  - When is chromatin present? - Interphase
  - When are chromosomes present? – Mitosis
  - What is the difference between an unreplicated chromosome and a replicated chromosome? – Single chromosome, double chromosome
  - What are sister chromatids? – held together by a centomere
- Levels of Biological Organization: cells, tissues, organs, organ systems, organisms

- Cancer:
    - What are the causes of cancer? - the uncontrolled growth and division of cells – a failure in the regulation of the cell cycle. When unchecked, cancer cells can kill an organism by crowding out normal cells, resulting in the loss of tissue function.
    - How can you prevent cancer? –
        - Stay out of sun, don't smoke or be around people that do, stay away from asbestos
        - the tumors could be removed if it hasn't spread but if it has spread, you should leave the primary tumor in.
    - What are carcinogens? - substances and agents that are known to cause cancer
    - What does metastasize mean? – spread of cancer from the primary site to other parts of the body
    - What is a tumor? – masses of cells
    - What are the two types of tumors?
        - Benign (ben-good): are noncancerous tumors and does not spread to healthy tissue or other parts of the body.
        - Malignant (mal-bad): are cancerous tumors that invade and destroy surrounding tissue.
    - What is cyclin? - proteins that bind to enzymes called cyclin-dependent kinases
        - Cyclin-dependent kinase (CDKs) – enzymes that cyclin binds to in the stages of interphase and mitosis to start the various activities that take place in the cell cycle. Different cyclin/CDK combination control different activities at different stages in the cell cycle. The picture above illustrates where some of the important combinations are active.
- What is the difference between haploid and diploid?
    - Haploid – a cell with n number of chromosomes. Haploid comes from the Greek word haploos, meaning single.
    - Diploid – a cell that contains 2n number of chromosomes
- What are homologous chromosomes? - the chromosomes that make up a pair, one chromosome from each parent.
    - Why do somatic (body) cells have homologous chromosomes? – same size/length, same centromere position, usually contain genes for the same trait
- How many chromosomes does a human have? How many pairs of chromosomes? – 46, 23 pairs
- What is crossing over? - a process during which chromosomal segments are exchanged between a pair of homologous chromosomes. Genetic variation increases because of it.
    - When does it happen? – Prophase I
- Compare mitosis and meiosis. – See chart above

DNA and RNA Unit

- Chapter 12
- Vocabulary -Notes
- What experiments led up to the discovery of DNA being the hereditary material?
    - The discovery that DNA is the genetic code involved many experiments.
        - Experiments by Griffith, Avery, Hershey and Chase, Watson and Crick.

- Proteins thought to be genetic material before discovery.

- Know what the following scientists did: Griffith, Avery, Hershey and Chase, Watson and Crick, and Rosalind Franklin

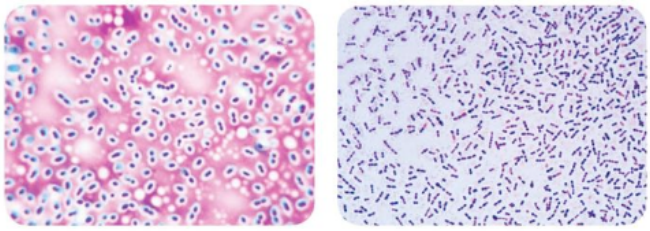


Figure 12.1 The smooth (S) strain of *S. pneumoniae* can cause pneumonia, though the rough (R) strain is not disease causing. The strains can be identified by the appearance of the colonies.

Smooth strain—*S. pneumoniae* **Rough strain—*S. pneumoniae***

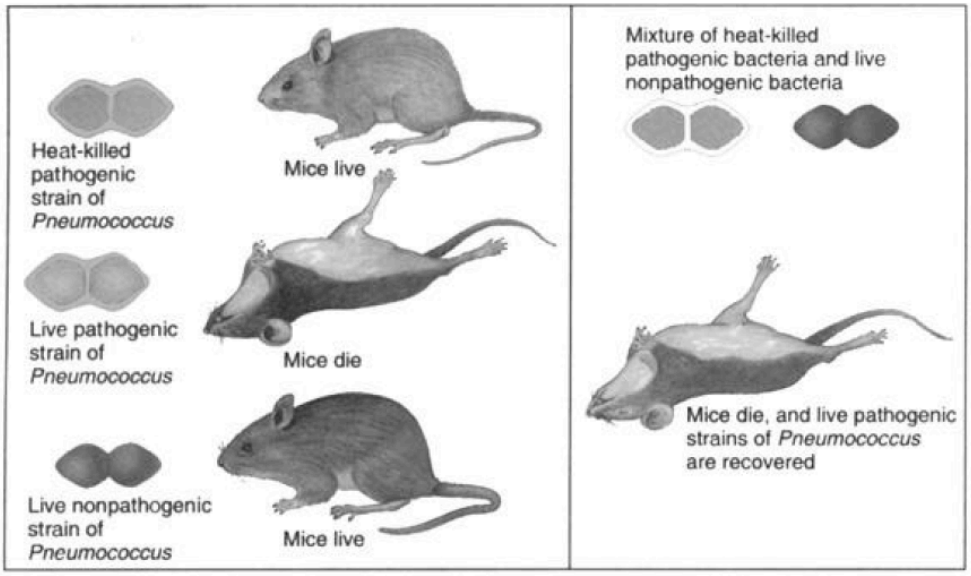


Figure 6.1
Griffith's discovery of the "transforming principle."

Figure 12.6 Rosalind Franklin's Photo 51 and X-ray diffraction data helped Watson and Crick solve the structure of DNA. When analyzed and measured carefully, the pattern shows the characteristics of helix structure.

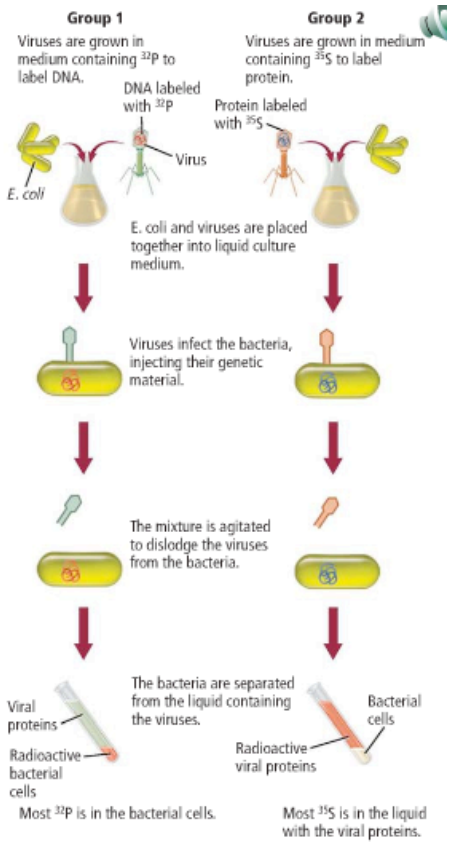


Figure 12.3 Hershey and Chase used radioactive labeling

Concepts in Motion

Interactive Table To explore more about Hershey and Chase, visit biologygmh.com.

Table 12.1 Summary of Hershey-Chase Results

Group 1 (Viruses labeled with ^{32}P)		Group 2 (Viruses labeled with ^{35}S)	
Infected Bacteria	**Liquid with Viruses**	**Infected Bacteria**	**Liquid with Viruses**
• Labeled viral DNA (^{32}P) found in the bacteria • Viral replication occurred • New viruses contained ^{32}P	• No labeled DNA • No viral replication	• No labeled viral proteins (^{35}S) • Viral replication occurred • New viruses did not have a label	• Labeled proteins found • No viral replication

Figure 12.5 Chargaff's data showed that though base composition varies from species to species, within a species C = G and A = T.

Chargaff's Data

	Base Composition (Mole Percent)			
Organism	A	T	G	C
Escherichia coli	26.0	23.9	24.9	25.2
Yeast	31.3	32.9	18.7	17.1
Herring	27.8	27.5	22.2	22.6
Rat	28.6	28.4	21.4	21.5
Human	30.9	29.4	19.9	19.8

- **Know the scientists and what they did to determine that DNA was the heredity molecule and the scientists that discovered the structure of DNA.**

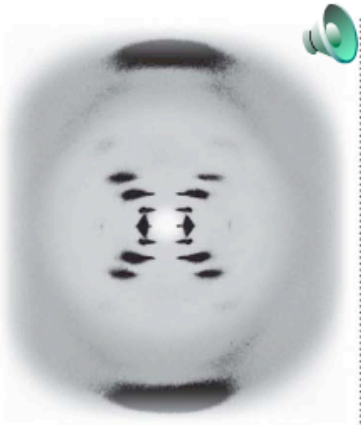


Figure 12.6 Rosalind Franklin's Photo 51 and X-ray diffraction data helped Watson and Crick solve the structure of DNA. When analyzed and measured carefully, the pattern shows the characteristics of helix structure.

X-ray diffraction Wilkins was working at King's College in London, England, with a technique called X-ray diffraction, a technique that involved aiming X rays at the DNA molecule. In 1951, Franklin joined the staff at King's College. There she took the now famous Photo 51 and collected data eventually used by Watson and Crick. Photo 51, shown in **Figure 12.6,** indicated that DNA was a **double helix,** or twisted ladder shape, formed by two strands of nucleotides twisted around each other. The specific structure of the DNA double helix was determined later by Watson and Crick when they used Franklin's data and other mathematical data. DNA is the genetic material of all organisms, composed of two complementary, precisely paired strands of nucleotides wound in a double helix.

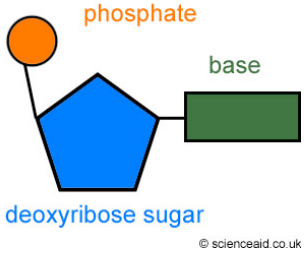
Watson and Crick Watson and Crick were working at Cambridge University in Cambridge, England, when they saw Franklin's X-ray diffraction picture. Using Chargaff's data and Franklin's data, Watson and Crick measured the width of the helix and the spacing of the bases. Together, they built a model of the double helix that conformed to the others' research. The model they built is shown in **Figure 12.7.** Some important features of their proposed molecule include the following:

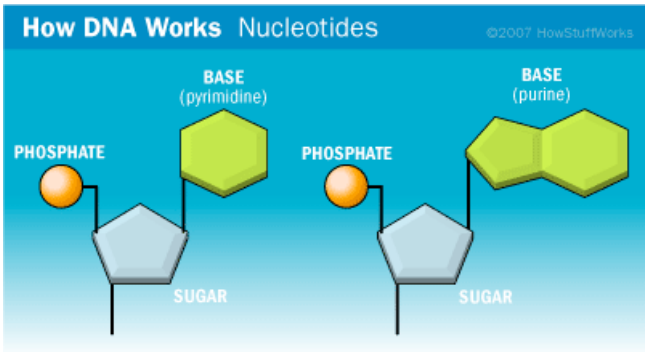
1. two outside strands consist of alternating deoxyribose and phosphate
2. cytosine and guanine bases pair to each other by three hydrogen bonds
3. thymine and adenine bases pair to each other by two hydrogen bonds

DNA structure DNA often is compared to a twisted ladder, with the rails of the ladder represented by the alternating deoxyribose and phosphate. The pairs of bases (cytosine–guanine or thymine–adenine) form the steps, or rungs, of the ladder. A purine base always binds to a pyrimidine base, ensuring a consistent distance between the two rails of the ladder. This proposed bonding of the bases also explains Chargaff's data, which suggested that the number of purine bases equaled the number of pyrimidine bases in a sample of DNA. Remember, cytosine and thymine are pyrimidine bases, adenine and guanine are purines, and C = G and A = T. Therefore, C + T = G + A, or purine bases equal pyrimidine bases. Complementary base pairing is used to describe the precise pairing of purine and pyrimidine bases between strands of nucleic acids. It is the characteristic of DNA replication through which the parent strand can determine the sequence of a new strand.

Figure 12.7 Using Chargaff's and Franklin's data, Watson and Crick solved the puzzle of the structure of DNA.

- Bacteriophage – used by Hershey and Chase, a type of virus that attacks bacteria. In their experiment the bacteriophage was made of DNA and protein.
- Nucleotides: the different kinds for DNA and RNA
    - **There are 4 different kinds of nucleotides – the only difference is the type of nitrogenous base: thymine, adenine, cytosine, and guanine. In RNA there is Uracil instead of thymine.**
- What are the base-pairing rules?
    - DNA
        - Adenine pairs with Thymine
        - Guanine pairs with Cytosine
    - RNA – no Thymine, but Uracil
        - Adenine pairs with Uracil
        - Guanine pairs with Cytosine
- Hydrogen bonding: double and triple bonds
    - Adenine pairs with Thymine forming a **double hydrogen bond**
    - Cytosine pairs with Guanine forming a **triple hydrogen bond**
    - What is the structure of DNA?





    - DNA – 3 parts
        - Phosphate group
        - Sugar (dexoyribose)
        - Nitrogenous bases (A,T, G, and C)
- How does the structure of DNA enable it to reproduce itself accurately?
    - Each strand acts as a template for building a new identical strand of DNA with the help of many enzymes.
- Semi-conservative – only half of the original DNA molecule is conserved in each new strand. In DNA replication there are two identical copies (strands) of DNA, Each new molecule consists of a new and original strand.
- **How does replication occur? What are the steps?**

- Main Idea – DNA replicated by making a strand that is complementary to each original strand.

Semiconservative Replication

When Watson and Crick presented their model of DNA to the science community, they also suggested a possible method of replication—semiconservative replication. During **semiconservative replication,** parental strands of DNA separate, serve as templates, and produce DNA molecules that have one strand of parental DNA and one strand of new DNA. Recall from Chapters 9 and 10 that DNA replication occurs during interphase of mitosis and meiosis. An overview of semiconservative replication is in **Figure 12.10.** The process of semiconservative replication occurs in three main stages: unwinding, base pairing, and joining.

Unwinding DNA helicase, an enzyme, is responsible for unwinding and unzipping the double helix. When the double helix is unzipped, the hydrogen bonds between the bases are broken, leaving single strands of DNA. Then, proteins called single-stranded binding proteins associate with the DNA to keep the strands separate during replication. As the helix unwinds, another enzyme, RNA primase, adds a short segment of RNA, called an RNA primer, on each DNA strand.

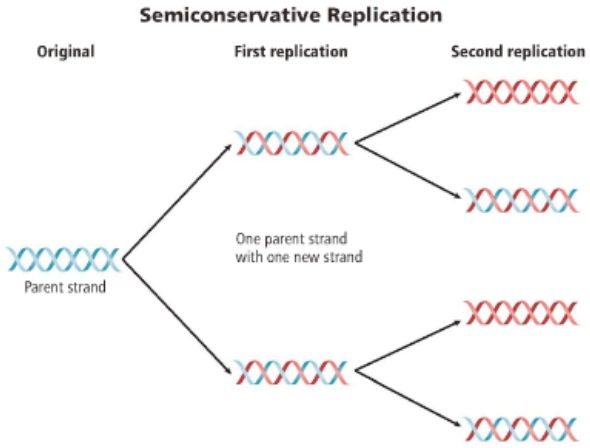


Figure 12.10 In semiconservative replication, the parental DNA separates and serves as templates to produce two daughter DNA, which then can separate to produce four DNA.

Base pairing The enzyme **DNA polymerase** catalyzes the addition of appropriate nucleotides to the new DNA strand. The nucleotides are added to the 3' end of the new strand, as illustrated in **Figure 12.11.** DNA polymerase continues adding new DNA nucleotides to the chain by adding to the 3' end of the new DNA strand. Recall that each base binds only to its complement—A binds to T and C binds to G. In this way, the templates allow identical copies of the original double-stranded DNA to be produced.

Notice in **Figure 12.11** that the two strands are made in a slightly different manner. One strand is called the leading strand and is elongated as the DNA unwinds. This strand is built continuously by the addition of nucleotides to the 3' end.

The other strand of DNA, called the lagging strand, elongates away from the replication fork. It is synthesized discontinuously into small segments, called **Okazaki fragments,** by the DNA polymerase in the 3' to 5' direction. These fragments are later connected by the enzyme DNA ligase. Each Okazaki fragment is about 100–200 nucleotides long in eukaryotes. Because one strand is synthesized continuously and the other is synthesized discontinuously, DNA replication is said to be semidiscontinuous as well as semiconservative.

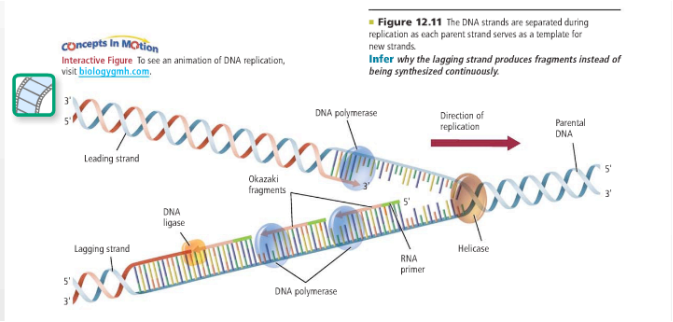


Figure 12.11 The DNA strands are separated during replication as each parent strand serves as a template for new strands.
Infer *why the lagging strand produces fragments instead of being synthesized continuously.*

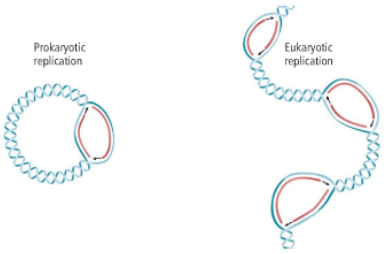


Figure 12.12 Eukaryotes have many origins of replication. Bacteria have one origin of replication, with the DNA replicating in both directions when it unzips.

Joining Even though the leading strand is synthesized continuously, in eukaryotic DNA replication there often are many areas along the chromosome where replication begins. When the DNA polymerase comes to an RNA primer on the DNA, it removes the primer and fills in the place with DNA nucleotides. When the RNA primer has been replaced, DNA ligase links the two sections.

Comparing DNA Replication in Eukaryotes and Prokaryotes

Eukaryotic DNA unwinds in multiple areas as DNA is replicated. Each individual area of a chromosome replicates as a section, which can vary in length from 10,000 to one million base pairs. As a result, multiple areas of replication are occurring along the large eukaryotic chromosome at the same time. Multiple replication origins look like bubbles in the DNA strand, as shown in **Figure 12.12.**

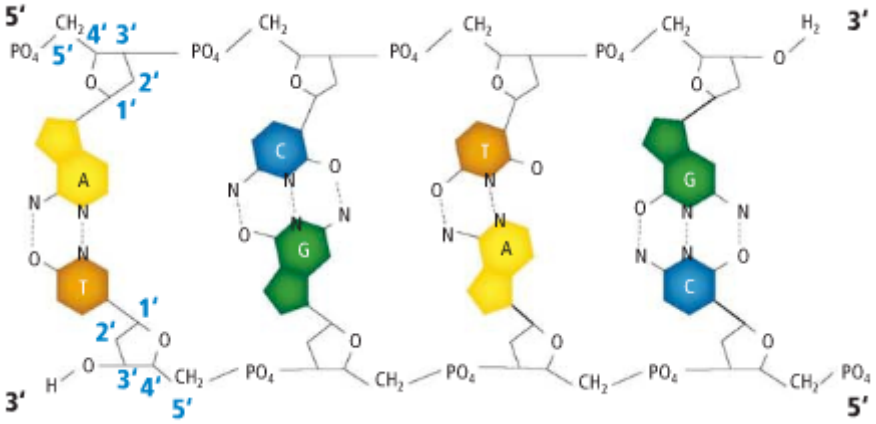
In prokaryotes, the circular DNA strand is opened at one origin of replication, as shown in **Figure 12.12.** Notice in the figure that DNA replication occurs in two directions, just as it does in eukaryotes. Recall from Chapter 7 that prokaryotic DNA typically is shorter than eukaryotic DNA and remains in the cytoplasm—not packaged in a nucleus.

- Helicase and ligase
  - Helicase – unwinds the DNA Double Helix and breaks the hydrogen bonds between each nitrogenous base this splitting the molecule into two. The splitting region is called the replication fork (origin of replication). Since

DNA is so big, multiple origins of replication (helicase) are formed to speed up replication.

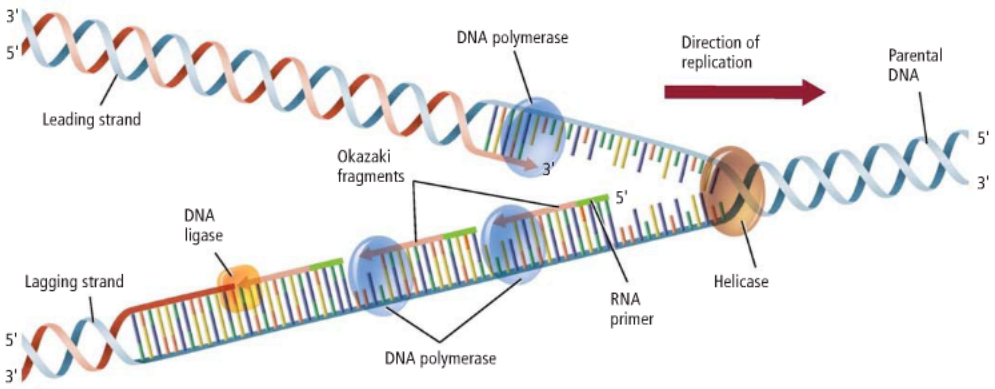
- Ligase – an enzyme that bonds or glues segments (Okazaki fragments) together

- Okazaki fragments – In DNA replication, one strand, the leading strand, is made continuously, the other is built in fragments called Okazaki fragments, which are bonded by ligase.
- DNA orientation (5′ and 3′) – **DNA polymerase always moves along the original DNA in the 3′ to 5′ direction.**



- **DNA replication**

Figure 12.11 The DNA strands are separated during replication as each parent strand serves as a template for new strands.
Infer *why the lagging strand produces fragments instead of being synthesized continuously.*



- DNA polymerase – In DNA replication, 2 enzymes of DNA polymerase attach to each strand and move along the molecule, base by base, adding the appropriate nitrogenous bases each time (A w/T and C w/ G).
- **Prokaryotic replication** -
- RNA polymerase – transcription requires this enzyme, which is similar to DNA polymerase. During transcription, RNA polymerase binds to DNA and separates

the DNA strands. RNA polymerase then uses one strand of DNA as a template from which nucleotides are assembled into a strand of RNA.

- Central Dogma

  Transcription Translation

  - DNA ➔ RNA ➔ Protein

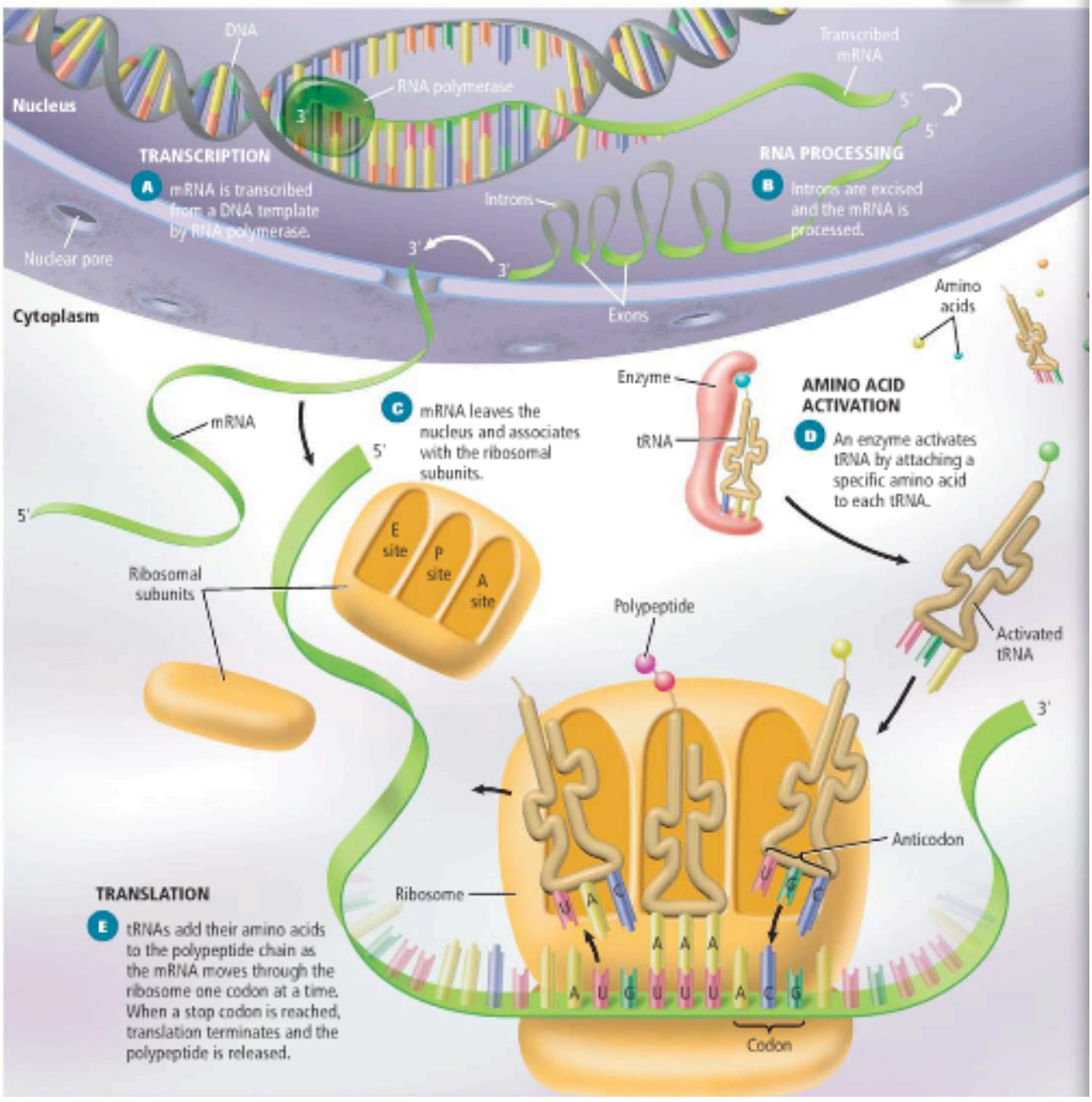
Replication

- Introns and exons
  - Introns – the DNA of eukaryotic cells contain these gene sequences of nucleotides, which **are not involved in the coding for proteins.**
  - Exons – the DNA sequence that **code for proteins**, because they are **expressed in proteins.**
- What are the differences between DNA and RNA?
  1. RNA has ribose, while DNA has Dexoyribose.
  2. RNA has Uracil, while DNA has Thymine.
  3. RNA is a single stranded nucleic acid, while DNA DNA is double stranded.

What are the steps involved in protein synthesis? (See Below)

Visualizing Transcription and Translation

Figure 12.15
Transcription takes place in the nucleus. Translation occurs in the cytoplasm and results in the formation of polypeptides.



- What are the different kinds of mutations?
  - Gene mutations – changes in single genes:
    - Point mutations – changes that involve one or few nucleotides because they occur at a single point in the DNA.

            - Substitutions – one base changed to another bases in the DNA sequences
        - Frameshift mutations – shift the reading frame of the DNA. They can then change every amino acid that follows the point of the mutation and change the protein that is produced.
            - Insertions – base inserted in the DNA sequence.
            - Deletions - base removed from the DNA sequence.
    - Chromosomal – in whole chromosomes:
        - Translocation – part of chromosome breaks off and attaches to another chromosome.
        - Duplications – produces an extra copy of part of a chromosome.
        - Deletion – loss of a part of a chromosome.
        - Inversion – reverses the direction of part of a chromosome.
- What are the effect of different kinds of mutations on cells and organisms?
    - Substitutions usually affect one amino acid, while insertions and deletions have much more drastic effects b/c
        - They could affect more than one amino acid.
        - Stop codon is still correct in substitution.
        - Maybe the same amino acid might result

Table 12.3 Mutations

Concepts In Motion
Interactive Table To explore more about types of mutations, visit biologygmh.com.

Mutation Type	Analogy Sentence	Example of Associated Disease
Normal	THE BIG FAT CAT ATE THE WET RAT	
Missense (substitution)	THE BIZ FAT CAT ATE THE WET RAT	Achondroplasia: improper development of cartilage on the ends of the long bones of arms and legs resulting in a form of dwarfism
Nonsense (substitution)	THE BIG RAT	Muscular dystrophy: progressive muscle disorder characterized by the progressive weakening of many muscles in the body
Deletion (causing frameshift)	THB IGF ATC ATA TET HEW ETR AT	Cystic fibrosis: characterized by abnormally thick mucus in the lungs, intestines, and pancreas
Insertion (causing frameshift)	THE BIG ZFA TCA TAT ETH EWE TRA	Crohn's disease: chronic inflammation of the intestinal tract, producing frequent diarrhea, abdominal pain, nausea, fever, and weight loss
Duplication	THE BIG FAT FAT CAT ATE THE WET RAT	Charcot-Marie-Tooth disease (type 1A): damage to peripheral nerves leading to weakness and atrophy of muscles in hands and lower legs
Expanding mutation (tandem repeats) Generation 1 Generation 2 Generation 3	 THE BIG FAT CAT ATE THE WET RAT THE BIG FAT CAT CAT CAT ATE THE WET RAT THE BIG FAT CAT CAT CAT CAT CAT CAT ATE THE WET RAT	Huntington's disease: a progressive disease in which brain cells waste away, producing uncontrolled movements, emotional disturbances, and mental deterioration

- Double helix – the structure of DNA, **a twisted ladder shape, formed by two strands of nucleotides twisted around each other.**

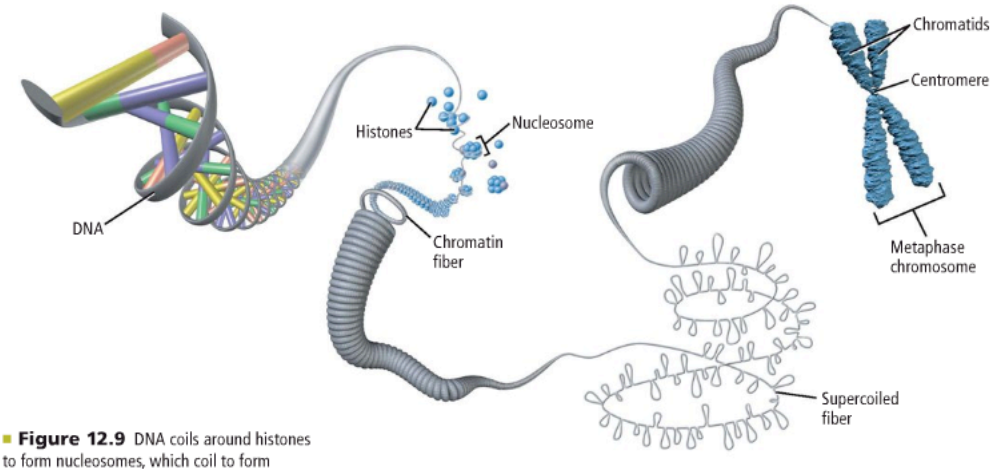


Figure 12.9 DNA coils around histones to form nucleosomes, which coil to form chromatin fibers. The chromatin fibers supercoil to form chromosomes that are visible in the metaphase stage of mitosis.

- Purines and Pyrimidines – **Because a pyrimidine (Single ring) pairs with a purine (double ring), the helix has a uniform width. (T w/ A and C w/ G)**
  - Purine – double ring

- Pyrimide – sing ring

- Structure of a nucleotide –

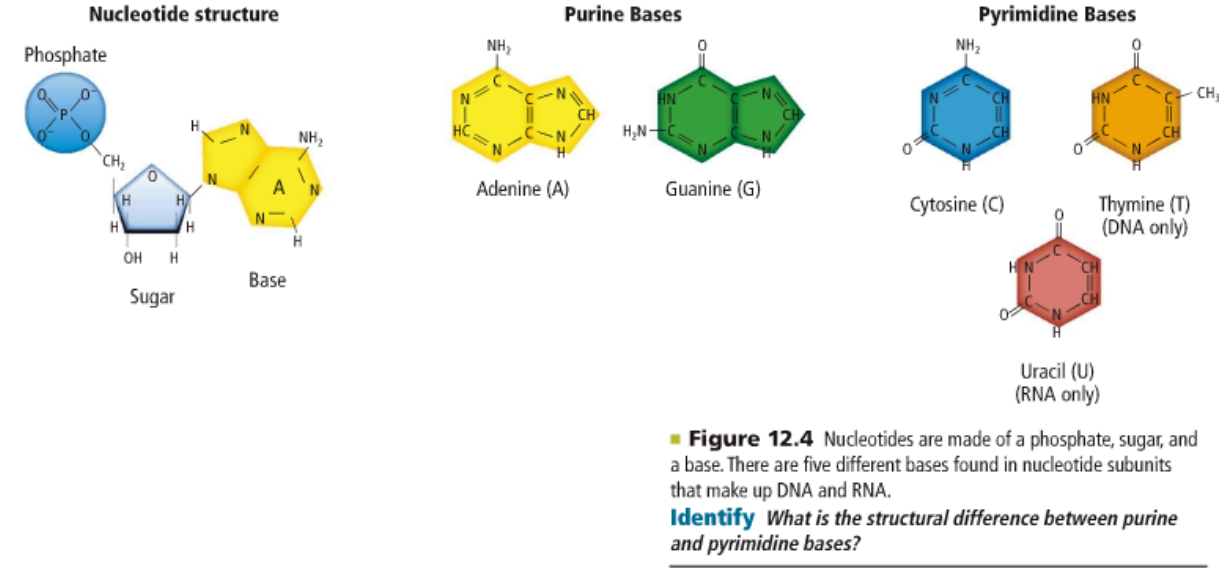


Figure 12.4 Nucleotides are made of a phosphate, sugar, and a base. There are five different bases found in nucleotide subunits that make up DNA and RNA.

Identify *What is the structural difference between purine and pyrimidine bases?*

- RNA:

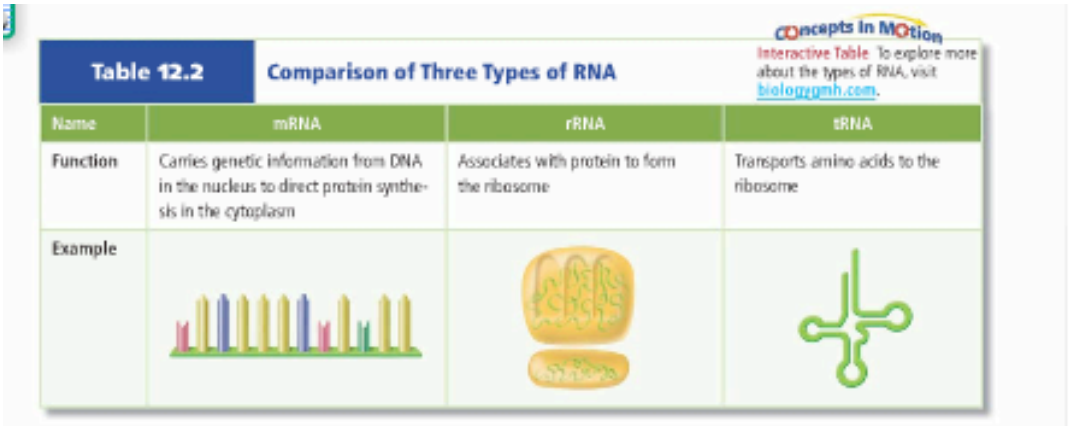


Table 12.2 Comparison of Three Types of RNA

Concepts in Motion
Interactive Table To explore more about the types of RNA, visit biologygmh.com.

Name	mRNA	rRNA	tRNA
Function	Carries genetic information from DNA in the nucleus to direct protein synthesis in the cytoplasm	Associates with protein to form the ribosome	Transports amino acids to the ribosome
Example			

  - Messenger (mRNA) – contains the instructions for assembling amino acids into proteins. It is the copy of DNA that goes to the ribosome.
  - Ribosomal (rRNA) – makes up ribosomes.

  - Transfer (tRNA) – transfers each amino acid to the ribosomes during the construction of a protein.
- Transcription and translation
  - Transcription – the process by which RNA is made from DNA. It occurs in the nucleus. It requires RNA polymerase. **Example TAC becomes TUG.**
  - Translation – the decoding of an mRNA message into a polypeptide/protein. It takes place in the ribosome. mRNA has to attach to the ribosome, which is located in the cytoplasm of the cell. Translation happens when the mRNA molecule attached to the ribosome, as each of the codons is read the proper amino acid is brought to the ribosome by tRNA. **Example AUG: Amino Acid Sequence – Met, tRNA anticodon – UAC.**
- Codons and anticodons
  - Codon – the genetic code is read three letters at a time. Each three-letter combination called a codon. Each codon specifies a single amino acid that is to be added to the polypeptide.
  - Anticodon – tRNA has **three unpaired bases** called anticodons in addition to one amino acid. Anticodons are complementary to one mRNA codon. **Ex. Codon: AUG – Anticodon: UAC**
- Mutagens – substances, which cause mutations such as chemicals and radiation mutations.
- DNA → RNA → Protein – **Central Dogma**

GOOD LUCK!