**Bio Midterm Review Study Guide**

***Chapter One:***

* Properties of Life:
  + Order: has highly ordered structure that typifies life🡪living cells are basis of this complex organization
  + Reproduction: organisms reproduce of their own kind
  + Growth & Development: inherited information in form of DNA controls pattern of growth & development in all organisms
  + Energy Processing: organisms use chemical energy stored in its food to power its own activities & chemical reactions
  + Response to environment: all organisms react & respond to environmental stimuli
  + Regulation: many types of mechanisms regulate organism’s internal environment, keeping it within limits that sustain life
  + Evolutionary Adaptation: adaptations such as camouflage evolve over many generations as individuals w/ traits best suited to their environment have greater reproductive success & pass their traits to offspring
* Life’s Hierarchy of Organization:
  + Biosphere: all environments on earth that support life
    - Madagascar
  + Ecosystem: consists of all organisms living in particular area, as well as physical components w/ which organisms interact, such as air, soil, water, & sunlight
    - Forest in Madagascar
  + Community: entire array of organisms in ecosystem
    - All organisms in forest
  + Population: all of individuals of particular species living in area
    - Group of ring-tailed lemurs
  + Organism: individual living thing
    - A ring-tailed lemur
  + Organ system: consists of several organs that cooperate in specific function
    - Nervous system
  + Organ: made up of several different tissues
    - Brain
  + Tissues: made up of group of similar cells that perform specific function
    - Nervous tissue
  + Cell: fundamental unit of life
    - Nerve cell
  + Organelle: membrane-enclosed structure that performs specific function in cell
    - Nucleus
  + Molecule: cluster of small chemical units called atoms held together by chemical bonds
    - DNA
* Prokaryotic vs. Eukaryotic Cell:
  + The cell is level at which properties of life emerge
    - Can regulate its internal environment, take in & use energy, respond to its environment, & develop & maintain its complex organization
    - All organisms are composed of cells
    - Cells are subunits that make up multicellular organisms
  + All cells:
    - Are enclosed by membrane that regulates massage of materials btw cell & its surroundings
    - Use DNA as its genetic information
  + Prokaryotic cells:
    - Were first to evolve
    - Much simpler & smaller than eukaryotic cell
    - Cells of microorganisms called bacteria
    - DNA not enclosed by nucleus
    - No membranous organelles
  + Eukaryotic Cells:
    - Evolved later
    - Larger & more complex
    - Cells of plants, fungi, animals, & protists
    - Subdivided by membranes into many functional compartments called organelles
    - DNA is enclosed by nucleus
  + Cells are example of biological systems
    - Systems Biology: constructing models for dynamic behavior of whole systems based on studying interactions among parts—like how parts of cell interact w/ each other
* Ecosystems:
  + Producers: plants that provide food for typical ecosystem through photosynthesis & etc.
    - Absorbs water & CO2🡪converts them to oxygen & release it
  + Consumers: organisms that eat plants & other animals
    - Take in O2 (oxygen) from air🡪release CO2
  + Decomposers: act as recyclers, changing complex matter into simpler mineral nutrients that plants can absorb & use
    - Small animals, fungi, bacteria in soil
  + 2 Major Processes🡪*recycling of chemical nutrients* & *flow of energy*
    - The most basic chemicals necessary for life: CO2, water, oxygen, minerals🡪**cycle within ecosystem** from air & soil to plants, to animals & decomposers, then back to air & soil
    - Ecosystem **gains & loses energy** constantly🡪flows into ecosystem when plants absorb light energy from sun & convert it to chemical energy of sugars & other complex molecules. This is used as food by series of consumer & decomposers🡪while powering organisms, some of energy is converted to heat, which is lost
    - Chemical nutrients recycle; energy flows through, entering as light & exiting as heat
* Domains of Life:
  + Domain Bacteria: prokaryotes that are most diverse & widespread
  + Domain Archaea: prokaryotes that live in Earth’s most extreme environments
  + Domain Eukarya: all organisms w/ eukaryotic cells
    - Protists: diverse collection of mostly single-celled organisms & some simple multicellular ones; many kingdoms
    - Kingdom Plantae: plants that can produce their own food through photosynthesis
    - Kingdom Fungi: diverse group whose members decompose remains of dead organisms & organic wastes & absorb nutrients into their cells
    - Kingdom Animalia: obtains food through ingestion
* Evolution/Natural Selection:
  + Evolution: Darwin’s idea that species living today are descendants of ancestral species
  + Natural Selection: Darwin’s second point that proposed mechanism for evolution🡪idea that:
    - 1. Individuals in population vary in traits, many are passed on from parent to offspring
    - 2. population can produce far more offspring than environment can support, so individuals w/ favorable traits to their environment have better reproductive success, while individuals w/ weaker traits die off without reproducing, so over time, larger number of organisms have favorable trait
* Elements of Scientific Experiment:
  + Deductive vs. Inductive Reasoning:
    - Inductive Reasoning: collecting & analyzing observations can lead to conclusions based on type of logic🡪derives generalization from many observations
    - Deductive reasoning: logic flows from general premises to specific results expected if premises are all true🡪predicts specific outcomes from general premise
  + Qualitative vs. Quantitative Data:
    - Qualitative: descriptive
    - Quantitative: numerical
  + Theory vs. Hypothesis:
    - Theory: explanation of idea that is broad in scope & supported by large body of evidence (Ex. Theory of Evolution)
    - Hypothesis: proposed explanation for set of observations🡪must be testable/falsifiable
  + Steps of Experiment:
    - Observation: flashlight does not work
    - Question: why does flashlight not work?
    - Hypothesis: dead batteries
    - Prediction: replacing batteries will fix problem
    - Experiment: test prediction by replacing batteries
    - Retest if necessary
  + Controlled Experiment: one that is designed to compare experimental group to control group, which is zero or normal level of IV
    - A control provides basis of comparison to experimental group

***Chapter Two:***

* Elements:
  + Substance that cannot be broken down to other substances by ordinary chemical means.
    - There are 92 elements that occur naturally, in addition to synthetic elements.
  + *Trace Elements:* Elements needed by all forms of life, but in minimal quantities
    - Boron, chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, silicon, tin, vanadium, zinc
    - 3 Major Ones: Iron, Iodine, Fluoride (form of fluorine)
      * Iodine:
        + Required only by certain species
        + Need tiny amounts daily
        + Essential for production of hormone produced in thyroid gland
        + Deficiency: goiter — thyroid gland can grow to abnormal size. Linked to mental retardation
        + Sources: iodized salt, seafood, strawberries, leafy greens
      * Fluoride:
        + Element found in Earth’s crust; found in small amounts in all water sources
        + Many areas add fluoride to water treatment processes; prevents tooth decay
        + Found in dental products
      * Iron:
        + Trace element commonly added to food
        + Metal element plays vital role in humans
        + Transports oxygen throughout body
        + Used in energy metabolism, gene regulation, cell growth
        + Critical in hemoglobin protein
        + Sources: red meats, egg yolks, leafy greens, cereals & grains.
        + Iron reacts w/ hydrochloric acid & other chemicals in digestive tract 🡪changes it into absorbable form
        + Deficiency: difficulty transporting oxygen, lack of energy, tiredness🡪called anemia, sickle cell anemia
  + *Compounds:* substance consisting of two or more different elements combined in fixed ratio.
    - Much more common than pure elements—mostly consists of only two elements (NaCl, H2O).
    - Most compounds in living organisms have at least 3 or 4 elements
      * sugar: carbon, hydrogen, oxygen
      * Proteins: carbon, hydrogen, oxygen, nitrogen, sulfur
    - Oxygen, Carbon, Hydrogen, & Nitrogen make up 96% of your body weight.
      * Oxygen: 65%
      * Carbon: 18.5%
      * Hydrogen: 9.5%
      * Nitrogen: 3.3%
* Atoms:
  + Smallest unit of matter that still retains properties of element
  + Each element is made up of one kind of atom.
  + Consists of protons, neutrons, electrons
    - Proton: subatomic particle w/ positive charge. Found in nucleus
    - Neutron: electrically neutral subatomic particle found in nucleus
    - Electron: subatomic particle w/ negative charge moving around nucleus.
  + *Atomic Number*: number of protons in atom of particular element. Each element has unique atomic number
  + *Mass Number/Atomic Mass*: sum of number of protons & neutrons in its nucleus \*\*different isotopes of element can have same atomic number but different atomic mass\*\*
  + *Isotopes*: atoms of element w/ same number of protons but different number of neutrons. Number of protons & electrons is always same. Behaves identically in chemical reactions
    - Ex. Carbon-12 (12C) w/ 6 neutrons, 6 Protons; Carbon-13 (13C) w/ 7 neutrons & 6 protons
    - Radioactive Isotopes: nucleus decays spontaneously, giving off particles of energy called radiation. Can be helpful but can also damage cells in organisms.
* Chemical Bonds:
  + *Electron Shells:* energy level representing distance of electron from nucleus
    - Electrons are only subatomic particle directly involved in chemical activity of atom.
    - The further electron is from nucleus, greater its energy
    - The number of electron shells depends on element’s atomic number
    - *Orbital:* discrete volumes of space in which electrons are most likely to be found within each electron shell
      * Each orbital holds max. 2 electrons
        + 1st electron shell🡪1 orbital🡪2 electrons
        + 2nd + 3rd electron shells🡪 4 orbitals 🡪 8 electrons
    - Number of electrons in outermost shell determines chemical properties. Atoms w/ unpaired electrons in their outer shells are more likely to react w/ other atoms
    - *Chemical Bonds:* when two atoms w/ incomplete outer shells react, each atom will share, donate, or receive electrons so that both atoms end up w/ complete outer shells.
      * *Valence Shells:* outermost shell
  + Covalent Bond: strongest type of chemical bond in which two atoms share one or more pairs of outer-shell electrons
    - Two or more atoms held by covalent bonds form *molecule*
      * Ex. 2 hydrogen atoms form H2
      * The valence (number of additional electrons needed to fill outer shell) determines number of covalent bonds able to form
    - Electronegativity: Atom’s attraction for shared electrons
      * More electronegative atom is, more it pulls shared electrons toward nucleus
        + Causes nonpolar or polar bonds (see below)
    - Polar Covalent Bonds: covalent bond btw atoms that differ in electronegativity (how much atom attracts shared electrons from other atoms). Shared electrons are pulled closer to more electronegative atom, making it slightly negative & other atom slightly positive.
    - Nonpolar Covalent Bonds: covalent bond in which electrons are shared equally btw two atoms of similar electronegativity
    - Difference btw Two:
      * Polar Covalent Bonds are bonds btw atoms of different electronegativities, while Nonpolar Covalent Bonds are bonds btw atoms of similar or identical electronegativities. In polar bonds, shared electrons spend more time near more electronegative atom, making one atom slightly positive & other slightly negative. But in nonpolar bond, both atoms are neutral because there is equal distribution of charges.
    - O2 & H2 (Oxygen & Hydrogen) are comprised of 1 element. Oxygen has double bond (shares 2 pairs of electrons), while hydrogen has single bond (shares 1 pair)
    - Covalent bonds form w/ nonmetal & nonmetal
  + Ionic Bond: When atoms interact, one atom donates its single outer electron(s)🡪other atom accepts donation
    - Electrons are negatively charged particles; Moves one negative charge to another atom
    - Creates ions: atom or molecule w/ electrical charge resulting from gain or loss of one or more electrons.
      * Two ions w/ opposite charges attract each other. When this attraction holds them together, it is *ionic bond*. Result is electrically neutral
    - Ex. NaCl🡪type of salt
    - Ionic bonds form w/ metal & nonmetal
  + Difference btw Two:
    - Covalent bonds share electrons while ionic bonds mean that electron is completely stripped away from one atom & given to another due to electronegativity.
  + Hydrogen Bond:
    - Water molecules are polar because elements that make up water share polar covalent bond, which is uneven sharing of electrons. Because oxygen is more electronegative than hydrogen, oxygen molecules pull hydrogen molecules’ shared electrons more closely towards its nucleus. Therefore, electrons spend more time near oxygen molecule than they do in hydrogen molecule. Because electrons are unequally shared btw two atoms, oxygen atom is slightly negative & hydrogen atom is partially positive, which makes water molecule polar.
    - Hydrogen bonds form btw water molecules because of polarity of water molecules. **Hydrogen bonds form when partially positive atom is attracted to partially negative atoms that are in polar covalent bond.** Because oxygen molecule is partially negative, it is electrically attracted to hydrogen, which is partially positive. Other way around, hydrogen molecule, which is partially positive, would be attracted to partially negative oxygen molecule, too. Each water molecule can form up to four hydrogen bonds.
* Properties of Water:
  + *Cohesion*: tendency of molecules of same kind to stick together. Stronger for water than for most other liquids. Caused by water molecules’ polarity & hydrogen bonds that form btw them.
    - Example: trees use cohesion to transport water molecules; water molecules have “skin” or outer shell that keeps them in droplet form. Reason why lots of energy is needed for water to evaporate.
    - Surface Tension: measure of how difficult it is to stretch or break surface of liquid. Hydrogen bonds & cohesion give water very high surface tension.
  + *Adhesion*: clinging of one substance to another or attraction btw different types of molecules. Caused by electrostatic forces, or attraction btw opposite charges. Opposite of cohesion.
    - Example: Water droplets forming on trees & staying on needles; water spilling out of glass. Water spreads out because adhesive forces overpower cohesive forces.
  + *Water’s Hydrogen Bonds Moderate Temperature*: water has stronger resistance to temperature change than most other substances because bonds are so strong—greater resistance to heat.
    - Heat: amount of energy associated w/ movement of atoms & molecules in body of matter
    - Temperature: measures intensity of heat—or average speed of molecules rather than total amount of heat energy
    - Evaporative Cooling: when substance evaporates, surface of liquid that remains cools down. Caused because molecules w/ greatest energy leave
    - Examples: Oceans store heat from sun during warm periods. Water absorbs & releases heat more slowly than land.
  + *Ice is Less Dense than Liquid Water:* 
    - Solid Ice: Hydrogen bonds are rigid & stable—more spaciously arranged
    - Liquid Water: hydrogen bonds are unstable—constantly break & reform, so it has more molecules
    - Ice crystals have fewer molecules than equal volume of water, so ice is less dense than liquid water & would float on top of it.
    - Examples: If ice sank, rivers, lakes, etc. would freeze, ice floats on surface & insulates bodies of water, animals are able to survive in water
  + *Water is Solvent of Life*: special property of water that allows it to dissolve many substances
    - Water dissolves more substances than any other liquid
    - It can dissolve ionic compounds & proteins, if they have ionic or polar regions on their surface
    - Necessary for all life on earth—wherever water goes, it carries nutrients, minerals, & chemicals that support life.
    - Example: water dissolving salt crystal. Sodium & chloride ions are exposed to water, & these ions & water molecules are attracted to each other because of their opposite charges—oxygen ends have partial negative charge & cling to positive sodium ions, & hydrogen ends have partial positive charge & cling to negative chloride ions.
* *Chemical Reactions*: breaking & making of chemical bonds, leading to changes in composition of matter
  + Reactants: starting material in chemical reaction (found on left side of arrow)
  + Products: ending material in chemical reaction (found on right side of arrow)
  + Example: photosynthesis
* Acid vs. Base:
  + Acids: high concentration of hydrogen ions, low concentration of hydroxide ions. Increases hydrogen ion concentration in solution
  + Bases: high concentration of hydroxide ions, low concentration of hydrogen ions. Substance that decreases hydrogen ion concentration in solution.
  + Chemical compound:
    - Acids: donates hydrogen atoms (H+) to solution
      * Ex. Hydrochloric Acid, Lemon Juice, Gastric Acid
    - Bases: Accepts & removes hydrogen atoms from solution. It does this by donating hydroxide ions (OH-) to solution.
  + Buffering System: found in biological fluids; minimizes changes in pH. Keeps pH levels stable. Accepts hydrogen or donates hydrogen to keep levels stable.
  + *pH Scale:* measure of relative acidity of solution. Measures amount of hydrogen & hydroxide ions. pH stands for Potential of Hydrogen. Each unit represents tenfold change in hydrogen concentration.
    - 0🡪most acidic; 14🡪most basic.
    - 0-6🡪acid
    - 7 🡪 neutral
    - 8-14🡪bases

***Chapter Three:***

* Organic Compounds: Carbon based molecules
  + Carbon is lead element in chemistry of life because they can form up to 4 covalent bonds, & can branch off up to 4 directions
  + *Hydrocarbons:* Compounds composed of only carbon & hydrogen
    - Methane, propane
    - Components of fats🡪provide fuel for your body cells
  + *Carbon Skeleton:* chain of carbon atoms in organic molecule
    - Can be branched or unbranched
    - Can have double bonds, in which case 2 carbons are double bonded, resulting in 2 less hydrogen
  + *Isomers:* compounds w/ same chemical formula but different structural arrangements
    - Can result from different spatial arrangements of 4 elements bonded to carbon atoms
    - Different isomer shapes can result in unique properties & are useful in pharmaceutical industry
  + Functional Groups:
    - Chemical groups that affect molecule’s function by participating in chemical reactions in characteristic ways
      * Groups are polar because oxygen & nitrogen are very electronegative
      * Polarity also makes them hydrophilic, or water loving
      * Methyl is nonpolar & nonreactive, but affects molecular shape
    - Hydroxyl Group: hydrogen atom bonded to oxygen atom, which in turn is bonded to carbon skeleton
    - Carbonyl Group: carbon atom linked by double bond to oxygen atom
      * If group is at end of carbon skeleton, it is aldehyde
      * If it is within chain, it is ketone
    - Carboxyl Group: carbon double bonded to oxygen atom & carbon is also bonded to hydroxyl group
      * Acts as acid by contributing H+ to solution
      * Compounds w/ carboxyl groups called carboxylic acids
        + Acetic acid
    - Amino Group: nitrogen bonded to two hydrogens & carbon skeleton
      * Acts as base by picking up H+ in solution
      * Organic compounds w/ amino group are called amines
      * Building blocks of proteins called amino acids because they contain amino & carboxyl group
    - Phosphate Group: consists of phosphorus atom bonded to four oxygen atoms
      * Compounds w/ phosphate groups are called organic phosphates
      * Involved in energy transfers
        + ATP
* Molecules (Monomers & Polymers):
  + *Macromolecule:* carbohydrates, lipids, proteins, nucleic acids
  + *Polymer:* chains of smaller molecules joined to form macromolecules. Large molecule consisting of many identical or similar building blocks strung together
  + *Monomer:* building blocks of polymers
  + *Dehydration Reaction:* process in which cells link monomers together to form polymer. unlinked monomer has hydrogen atom & hydroxyl group on each end. For each monomer added, water molecule is released
  + *Hydrolysis:* breaking of bonds btw monomers by adding water molecule btw linked monomers, separating them
  + *Enzymes:* specialized macromolecules that speed up chemical reactions in cells. (proteins)
  + *Diversity of Macromolecules:*
    - DNA is built from 4 macromolecules called nucleotides
    - All proteins from living things are made from same 20 amino acids

Monomer🡪 *dehydration reaction*🡪polymer🡪macromolecule🡨*hydrolysis*🡨monomer

* Carbohydrates:
  + a class of molecules ranging from small sugar molecules to large polysaccharides
  + Monosaccharaides:
    - *Monosaccharaides:* carbohydrate monomers, or single unit sugars
      * Single unit sugars can be hooked together by dehydration reactions to form complex sugars & polysaccharides
      * Molecular formulas are usually multiple of CH2O
      * Trademarks of Sugar: several hydroxyl groups, & carbonyl group
        + Hydroxyl group makes sugar alcohol
        + Carbonyl group, depending on location, makes it aldose or ketose
      * Monosaccharaides, mainly glucose, are main fuel for molecules in cellular work🡪cells release energy from glucose when they break it down
  + Disaccharide:
    - Cells construct disaccharides from two monosaccharide monomers by dehydration reaction. One monomer gives up hydroxyl group & other gives up hydrogen atom from hydroxyl group, releasing water molecule. Oxygen atom is left – links two monomers.
      * Sucrose: glucose monomer linked to fructose monomer
      * Maltose: two glucose monomers linked
  + Polysaccharides:
    - Macromolecules: polymers of hundreds to thousands of monosaccharaides linked together by dehydration reaction.
      * Functions as storage molecules or structural compounds
    - Starch:
      * Storage Polysaccharide in plants
      * Consists of entirely glucose molecules
      * Coiled into helix shape
      * Humans can hydrolyze starch cells to glucose🡪wheat, corn, rice
    - Glycogen:
      * Storage Polysaccharide in animals
      * More highly branched than starch
      * In humans, stored as granules in liver & muscle cells, which hydrolyze glycogen into glucose when needed
    - Cellulose:
      * Component of cell wall in plants
      * Monomers are linked together differently than in glycogen or starch🡪parallel to each other, joined by hydrogen bonds
      * Animals don’t have enzymes that hydrolyze glucose linkings in cellulose🡪not nutrient for humans
    - Chitin:
      * Structural polysaccharide used by insects & crustaceans to build external shell
      * Found in cell walls of fungi
* Lipids:
  + Diverse compounds that are grouped together because they are hydrophobic, or don’t mix well w/ water
    - Consists mainly of carbon & hydrogen atoms linked by nonpolar covalent bonds, so they don’t interact w/ water
    - They are also different from others because they are neither huge macromolecules nor polymers built from similar monomers
  + *Fats*: large lipid made up of two kinds of smaller molecules, glycerol & fatty acids
    - *Glycerol*: alcohol w/ 3 carbons, w/ hydroxyl group
    - *Fatty acid*: Carboxyl group & hydrocarbon chain (16 or 18 carbon)
      * Nonpolar hydrocarbon chain is reason facts are hydrophobic
  + *Unsaturated Fatty Acid:* has one fewer hydrogen atom on each carbon of double bond
    - Healthier🡪liquid at room temperature because kinks where double bonds are keep them from solidifying at room temperature
  + *Saturated Fatty Acid:* fatty acids w/ no double bonds in hydrocarbon chain & maximum number of hydrogen atoms
    - Unhealthier🡪can pack together at room temperature & solidifies. Can build up in arteries
  + *Trans Fats:* form of fat that can cause health risks because of hydrogenation, or process of converting unsaturated fats to saturated fats by adding hydrogen
  + Main function of fats is long-term energy storage
  + *Phospholipids:*
    - Major component of cell membranes
    - Structurally similar to fats, but only have 2 fatty acids attached to glycerol instead of 3
      * A negatively charged phosphate group is attached to glycerol’s 3rd carbon, making head hydrophilic & tail hydrophobic
      * Assembles to form cell membrane🡪hydrophobic tails cluster in center, & hydrophilic phosphate heads face water on either side of membrane
  + *Steroids*: lipids in which carbon skeleton contains four fused rings
    - Anabolic steroids: synthetic variants of testosterone
  + *Cholesterol*: common component in animal cell membranes that animals use as starting material to make other steroids
* Proteins:
  + Polymer of amino acids. Diversity is based on differing arrangements of common set of 20 amino acid monomers
  + *Amino acids:* all have amino group & carboxyl group that makes it acid🡪groups are covalently bonded to central carbon atom (alpha carbon)
    - Also bonded to alpha carbon is hydrogen atom & chemical group called R group—consists of one or more carbon atoms w/ various chemical groups attached
      * Composition & structure of R group determines properties of 20 amino acids
        + Leucine🡪hydrophobic; Serine🡪polar, hydrophilic R group
        + Aspartic acid🡪acidic, negatively charged
  + *Peptide Bond:* Bond formed when cells join amino acids together by dehydration reaction that links carboxyl group of one amino acid to amino group of next amino acid, removing water molecule
    - *Polypeptide:* additional amino acids added by same process to form amino acid chain
  + Most polypeptides are at least 100 amino acids long🡪each as unique sequence of amino acids
  + The specific shape of protein determines its function — can be twisted, coiled, or folded into 3D shape that’s unique
  + *Protein Shape:*
    - Most important role of protein is as enzymes
      * *Enzymes:* chemical catalysts that speed up & regulate all chemical reactions in calls
    - *Structural Proteins:* found in hair & fibers that make up connective tissues like tendons & ligaments
    - *Contractile Proteins:* found in muscle cells
    - *Defensive Proteins:* antibodies of immune system
    - *Signal Proteins:* hormones & chemical messengers that coordinate body activities by communicating btw cells
    - *Receptor Proteins:* built into cell membranes & transmit signals into cells
    - *Transport Proteins:* hemoglobin in red blood cells that delivers O2 to muscles & tissues, or move sugar molecules into cells for energy
    - *Storage Proteins:* ovalbumin, protein for egg white that serves as source of amino acids for embryos. Milk proteins provide amino acids for mammals, & plant seeds have storage proteins for embryos
    - Most proteins are shaped globular (enzymes). Structural proteins are called fibrous
      * Each protein has specific shape, & shape determines function. All proteins must recognize & bind to some other molecule to function, so it needs shape
      * Denaturation: polypeptide chains unravel, losing specific shape & function. Can be caused by changing heat of pH levels
  + *Protein Structure:*
    - Primary Structure: unique sequence of amino acids
    - Secondary Structure: parts of polypeptide coil or fold into local patterns
      * Results in secondary structure called alpha helix, certain folding results in beta pleated sheet
        + Patterns maintained by regularly spaced hydrogen bonds btw hydrogen & oxygen atoms along backbone of chain
    - Tertiary Structure: 3D shape formed by interactions btw R groups
    - Quaternary Structure: many proteins consist of two or more polypeptide changes formed into one functional macromolecule—results in association of polypeptides
* Nucleic Acids:
  + A polymer consisting of many nucleotide monomers; serves as blueprint for proteins and, through activities of proteins, for all cellular structures & activities
    - Nucleotides🡪monomers that make up nucleic acids
  + *Gene:* amino acid sequence of polypeptide is programmed by discrete unit of inheritance known as gene
    - Consists of **DNA** (deoxyribonucleic acid)🡪one of 2 types of nucleic acid (other is RNA)
    - Genetic materials that we inherit comes from DNA🡪DNA provides directions for its own replication
  + The genes in DNA build proteins through intermediary called **RNA** (ribonucleic acid)
    - In nucleus of eukaryotic cell, gene directs synthesis of RNA molecule🡪or, DNA is transcribed into RNA🡪the RNA molecule moves out of nucleus & interacts w/ protein-building machinery of cell🡪there, gene’s instructions, written in “nucleic acid language” are translated into “protein language”, amino acid sequence of polypeptide
  + A nucleotide contains 3 parts: phosphate group, sugar, & nitrogenous base
    - Phosphate group & sugar form repeating pattern for backbone of **double helix** structure of DNA
    - Nitrogen base is attached to sugar part of backbone🡪4 bases are adenine, thymine, guanine, & cytosine (thymine is replaced w/ uracil in RNA, & RNA is usually single polynucleotide strand while DNA is double helix)
      * Adenine pairs w/ Thymine
      * Guanine pairs w/ Cytosine

***Chapter Four:***

* Microscopes:
  + *Light Microscope:* visible light is passed through specimen, & then through glass lenses🡪the lenses bend light in such way that image is magnified as it is projected into eye or camera
  + *Electron Microscope:* focuses beam of electrons through specimen or onto its surface🡪higher resolution than light microscope
    - *Scanning electron microscope*: used to study detailed architecture of cell **surfaces**
      * Uses electron beam to scan surface of cell or other sample, usually coated w/ thin film of gold. Beam excites electrons on surface, electrons are detected by device that translates pattern into image projected onto video screen
    - *Transmission electron microscope*: used to study details of **internal** cell structure
      * Aims electron beam through very thin section of specimen, section stained w/ heavy metals, which attach to certain structures more than others. Electrons are scattered by more dense parts, image is created by pattern of transmitted electrons🡪uses electromagnets as lenses to bend paths of electrons
  + Advantages & Disadvantages:
    - Electron Microscopes have better **resolution** & **magnification** than light microscopes
      * *Resolution*: ability of optical instrument to show 2 nearby objects as separate
      * *Magnification*: increase in apparent size of object
    - However, light microscopes can be used to study living specimens, but electron microscopes cannot because process of preparing it will kill cell
  + *Cell Theory:* states that all living things are composed of cells & all cells come from other cells
* Prokaryotic Structure vs. Eukaryotic Structure:
  + All Cells:
    - Bounded by plasma membrane
    - One or more chromosomes carrying genes made of DNA
    - Contain ribosomes that make proteins
    - Has cytoplasm that makes up interior of cell
  + Prokaryotic Cells:
    - Bacteria & Archaea
    - DNA is coiled into region called nucleoid (not enclosed by membrane)
    - Ribosomes are smaller
    - Has cell wall outside of plasma membrane (plant cells have that too)
    - Has capsule outside cell wall that’s jellylike & sticky to help glue cell to surfaces
    - Has fimbriae, attachment structures on surface of some prokaryotes
    - Has flagella, locomotion organelle (some eukaryotic cells like sperm have flagella too, but not many)
  + Eukaryotic Cells:
    - Protists, fungi, plants, animals
    - Cytoplasm holds membranous organelles (see below)
    - Plant cells have cell wall, animal cells don’t
    - Membrane-enclosed nucleus holds DNA
* Eukaryotic Cell Organelles:
  + *Nucleus*: **contains most of cell’s DNA & controls cell’s activities by directing protein synthesis**🡪 associated w/ many proteins in chromosomes🡪proteins help organize & coil long DNA molecule
    - *Nucleolus*: prominent structure in nucleus where **ribosomal RNA (rRNA) is synthesized** according to DNA instructions
      * *rRNA:* exits nucleus through pores to cytoplasm, where they join to form functional ribosomes
      * *mRNA:* messenger RNA🡪transcription of protein synthesizing instructions written in gene’s DNA, & is translated by ribosomes into amino acid sequence of proteins
    - *Chromatin*: **complex of proteins & DNA** that looks like diffuse mass when cell isn’t dividing
    - *Nuclear Envelope:* double membrane that encloses nucleus🡪each of membranes is phospholipid bilayer w/ associated proteins, controls what goes in & out of nucleus
  + *Ribosomes:* cellular components that use instructions sent from nucleus to **carry out protein synthesis**
    - *Free Ribosomes*: suspended in fluid of cytoplasm
    - *Bound Ribosomes:* attached to outside of endoplasmic reticulum or nuclear envelope
  + *Endomembrane System*: internal membranes that are involved in most of cell’s functions, & some are physically connected & some are related by transfer of membrane segments by tiny vesicles**; many of these organelles work together in synthesis, distribution, storage, & export of molecules**
    - *Vesicles*: sacs made of membrane
    - *Endoplasmic Reticulum:* extensive network of **flattened sacs & tubules** that are **continuous within nuclear envelope**🡪enclose interior space that is separate from cytoplasmic fluid, **dividing cell** into separate functional compartments
      * *Smooth ER:* lacks attached ribosomes
        + Functions in variety of metabolic processes—like synthesis of lipids. Large amount of smooth ER in liver to metabolize alcohol & drugs. Stores calcium in muscle cells.
      * *Rough ER:* has ribosomes that stud outer surface of membrane
        + Makes more membrane by making phospholipids through enzymes of rough ER that are hen inserted into membrane. Thus, membrane grows, & portions of it are transferred to other components of endomembrane system as vesicles.
        + Makes proteins that will be inserted into growing membrane, then shipped to other parts of cell (secretory protein):

As polypeptide is synthesized by bound ribosome following mRNA instructions, it is threaded into rough ER cavity. As it enters, new protein folds into its 3D shape

Short chains of sugars are often linked to polypeptide, making molecule glycoprotein

When molecule is ready for export from ER, it is packaged in transport vesicle, vesicle that moves from one part of cell to another. This vesicle buds off from ER membrane

* + - *Golgi Apparatus*: consists of stacks of membranous sacs that modify, store, & ship products of endoplasmic reticulum🡪serves as molecular warehouse & finishing factory for ER manufactured products🡪flattened Golgi sacs are not connected, unlike ER sacs
      * 1. One side of Golgi serves as receiving dock for transport vesicles made by ER
      * 2. vesicle fuses w/ Golgi sac, adding its membrane & contents to receiving side
      * 3. Products of ER are modified during their transit through Golgi. Various enzymes modify carbohydrate portions of glycoproteins🡪molecular identification tags like phosphate groups are sometimes added to help Golgi sort & ship
      * 4. other side of Golgi, shipping side, makes new vesicles, which bud off & travel to other sites
    - *Lysosomes*: membranous sac of digestive enzymes🡪Membranes & enzymes of lysosomes are made by rough ER & processed in Golgi apparatus🡪provides acidic environment for enzymes while safely isolating them from rest of cell
      * *Digestive functions*🡪protists use them to engulf food particles into membranous sacs called food vacuoles🡪lysosomes fuse w/ food vacuoles to digest food. Nutrients are then released into cell fluid.
      * White blood cells engulf & destroy bacteria using lysosomal enzymes
      * Recycling center: damaged organelles or small amounts of cell fluid are surrounded by membrane🡪lysosome fuses w/ vesicle & dismantle its contents, making organic molecules available for reuse
    - *Vacuoles (plants only)*: large vesicles that have variety of functions:
      * Food vacuoles form as cell digests food
      * In plants, vacuoles have digestive function similar to lysosomes in animal cells
      * In flower petals, vacuoles have pigments that attract pollinating insects, or contain poisons that protects against herbivores
      * **Central Vacuole:** helps cell grow in size by absorbing water & enlarging🡪also stockpiles chemicals & acts as safe storage for toxic waste
    - *Nuclear Envelope:* \*\*see above in nucleus section\*\*
  + *Peroxisomes:* metabolic compartments that don’t originate in endomembrane system, but breaks down fatty acids to be used as cellular fuel, detoxify alcohol & other harmful compounds by producing hydrogen peroxide
  + *Mitochondria*: organelles that carry out **cellular respiration** in nearly all eukaryotic cells, converting **chemical energy of foods** such as sugars into chemical energy of molecule called **ATP**, which is main energy source for cellular work
    - *Structure:* 2 membranes that are phospholipid bilayers w/ embedded proteins & has 2 internal compartments🡪*intermembrane space*: space btw inner & outer membranes; *mitochondrial matrix*: contains mitochondrial DNA & ribosomes & enzymes that catalyze reactions of cellular respiration
      * Inner membrane is highly folded🡪folds are called *cristae*, which increase its surface area & therefore enhances ability to produce ATP
  + *Chloroplasts (plants only)*: photosynthesizing organelle of all photosynthetic eukaryotes
    - Enclosed by inner & outer membrane separated by thin intermembrane space
      * *Stroma:* thick fluid that contains chloroplast DNA & ribosomes that are found in inner membrane
      * *Thylakoids*: network of interconnected sacs inside chloroplast🡪stack of thylakoids are called *granum*, chloroplast’s solar power packs that trap solar energy
* Cell Surfaces: plasma membrane composed of phospholipid bilayer of hydrophilic heads & hydrophobic tails
  + *Cytoskeleton*: network of protein fibers extending throughout cytoplasm of cell🡪They function like skeleton, providing both structural support & cell motility🡪Internal movement & locomotion
    - *Microfilaments*: also called actin filaments; solid rods made of globular actin proteins arranged in twisted double chain to form 3D network just inside plasma membrane to **help support cell’s shape**
      * Also involved in **cell movements**🡪cause contraction of muscle cells
    - *Intermediate Filaments*: made of various fibrous proteins that supercoil into thicker cables; often more permanent fixtures of cell
      * Serve mainly to **reinforce cell shape** & to **anchor certain organelles**, like nucleus
    - *Microtubules*: straight, hollow tubes composed of globular tubulin proteins, which elongate by addition of tubulin proteins🡪contain centrioles
      * Microtubules **shape & support cell &** act as **tracks** along which organelles equipped w/ motor proteins can move
  + *Extracellular Matrix*: found in animal cells🡪helps hold cells together in tissues & protects & supports plasma membrane
    - Main components: glycoproteins (mainly collagen), & proteins bonded w/ carbohydrates
    - Collagen fibers are embedded in network of woven glycoproteins🡪ECM is attached to cell through other glycoproteins that bind to membrane proteins called **integrins**
      * *Integrins:* span plasma membrane, attaching on one side to ECM & attached to proteins connected to cytoskeleton microfilaments on other side🡪transmit signals btw ECM & cytoskeleton
* Cell Junction:
  + *Tight Junctions*: plasma membranes of neighboring cells are tightly pressed against each other & knit together by proteins
    - Forms continuous seals around cells, preventing leakage of fluid across layer of cells🡪ex. Digestive tract
  + *Anchoring Junctions*: function like rivets, fastening cells together into strong sheets; made of sturdy intermediate filaments made of keratin proteins
    - Common in tissues that stretch🡪ex. Heart or skin muscle
  + *Gap Junctions*: communicating junctions; channels that allow small molecules to flow through protein-lined pores btw cells
    - Ex. flow of ions through gap junctions in heart coordinates their contraction
    - Ex. Gap junctions are common in embryos, where communication btw cells is essential for development

***Chapter Five:***

* Passive Transport: diffusion across membrane w/ no energy investment🡪a cell does not have to do work when molecules diffuse across its membrane🡪most traffic across cell membranes occurs through diffusion
  + *Diffusion:* tendency for particles of any kid to spread out evenly in available space
  + *Concentration Gradient:* region along which density of chemical substance increases or decreases. Cells often maintain concentration gradients of ions across their membranes. When gradient exists, substances tend to move from where they are more concentrated to where they are less concentrated
  + *Net Movement:* direction that molecules move🡪from side where molecules are more concentrated to side where they are less concentrated 🡪diffusion *down* it’s concentration gradient
  + Small, nonpolar molecules like oxygen, carbon dioxide, can diffuse easily across phospholipid membrane, but ions & polar molecules can also diffuse through facilitated diffusion
* Osmosis: diffusion of water across selectively permeable membrane that allows some substances to cross more easily than others (ex. water)
  + If membrane is permeable to water but not to solute, like sugar…
    - Polar water molecules cluster around hydrophilic solute molecules
    - On side where there are more solute molecules, there are fewer water molecules available to cross membrane. Less concentrated solution w/ fewer solute molecules has more water molecules free to move.
    - There is net movement of water down its own concentration gradient, from solution w/ more free water molecules to one w/ fewer free molecules.
    - Difference in water levels🡪more water in side that started w/ more solute molecules
* Water Balance:
  + *Tonicity:* ability of surrounding solution to cause cell to gain or lose water. Tonicity of solution depends on its concentration of solutes that cannot cross plasma membrane relative to concentration of solutes inside cell.
    - *Hypertonic*: solution w/ higher solute concentration than that of cell
      * Water moves from inside cell to outside, causing cell to lose water & shrivel in both plant & animal cells (plasmolyzed)
    - *Hypotonic*: solution w/ solute concentration lower than that of cell
      * Water moves from outside cell to inside, causing cell to gain water. In animal cell, it may burst & become lysed, but in plant cell, it becomes turgid & firm, which is normal
    - *Isotonic*: solution w/ solute concentration equal to that of cell
      * The same amount of water enters & exits cell, or net movement of water is same. For animal cells, this is normal state, but for plant cells, this leaves them flaccid, or limp
  + *Osmoregulation:* control of water balance
* Facilitated Diffusion: process in which polar or charged substances can move across membrane w/ help of specific transport proteins (type of passive transport that doesn’t require cell energy). Driving force is concentration gradient.
  + A transport protein provides hydrophilic channel that some molecules or ions use as tunnel through membrane
  + Another type of protein binds its passenger, changes shape, & releases its passenger on other side
  + The transport protein is specific for substance it helps move across membrane🡪the greater number of transport proteins for particular solute, faster solute’s rate of diffusion across membrane
    - Sugars, amino acids, even water use facilitated diffusion to cross membrane
    - The diffusion of water into & out of certain cells (kidney, red blood cells, etc.) is possible through protein channel called *aquaporin*
* Active Transport: cell expends energy to move solute against its concentration gradient (across membrane toward side where solute is more concentrated) 🡪active transport allows cell to maintain internal concentrations of small molecules & ions that are different from concentrations in its surroundings.
  + The energy molecule ATP supplies energy for most active transport
    - The process begins when solute molecules on cytoplasmic side of membrane attach to specific binding sites on transport protein
    - ATP then transfers phosphate group to transport protein
    - Causing protein to change shape in such way that solute is released on other side of membrane
    - The phosphate group detaches, & transport protein returns to its original shape
  + *Exocytosis*: process used to export bulky materials like proteins or polysaccharides
    - A transport vesicle filled w/ macromolecules buds from Golgi apparatus & moves to plasma membrane🡪once there, vesicle fuses w/ plasma membrane, & vesicle’s contents spill out of cell when vesicle membrane becomes part of plasma membrane
  + *Endocytosis*: transport process opposite of exocytosis🡪a cell takes in large molecules, & depression in plasma membrane pinches in & forms vesicle, enclosing material that had been outside of cell
    - *Phagocytosis*: “cellular eating”🡪a cell engulfs particle by wrapping extensions called pseudopodia around it & packaging it within membrane enclosed sac large enough to be called vacuole🡪the vacuole then fuses w/ lysosome, whose hydrolytic enzymes digest contents of vacuole
    - *Pinocytosis*: “cellular drinking”🡪the cell “gulps” droplets of fluid into tiny vesicles. It takes in any & all solutes dissolved into droplets
    - *Receptor-Mediated Endocytosis:* highly selective🡪receptor proteins for specific molecules are embedded in regions of membrane that are lined by layer of coat proteins
* Forms of Energy:
  + *Energy:* capacity to cause change or to perform work. There are 2 types of energy:
    - *Kinetic Energy:* energy of motion. Moving objects can perform work by transferring motion to other matter
      * *Heat/Thermal Energy:* type of kinetic energy associated w/ random movement of atoms or molecules
    - *Potential Energy:* energy that matter possesses as result of its location or structure. Molecules possess potential energy because of arrangement of electrons in bonds btw their atoms
      * *Chemical Energy:* potential energy available for release in chemical reaction; most important type of energy for living organisms; energy that can be transformed to power to work of cell
* Energy Transformations:
  + *Thermodynamics:* study of energy transformations that occur in collection of matter
  + *First Law of Thermodynamics:* energy in universe is constant. Energy can be transferred & transformed, but it cannot be created or destroyed
    - *Entropy:* measure of disorder or randomness. More randomly arranged collection of matter is, greater its entropy. This is why heat energy cannot be used, & organisms can’t recycle their energy.
  + *Second Law of Thermodynamics:* energy conversions increase entropy (disorder) of universe
  + *Cellular Respiration:* chemical energy stored in organic molecules is converted to form that cell can use to perform work🡪waste products are mostly carbon dioxide & water
* ATP: (adenosine triphosphate) powers nearly all forms of cellular work. Adenosine part consists of adenine (nitrogenous base) & ribose, sugar. Triphosphate part is chain of three phosphate groups that are negatively charged. Phosphate group bonds are unstable & can be easily broken by hydrolysis.
  + *Exergonic*: chemical reaction that releases energy. Exergonic reaction begins w/ reactants whose covalent bonds contain more energy than those in products. Reaction releases to surroundings amount of energy equal to diff in potential energy btw reactants & products
    - *Ex.* burning wood🡪energy-rich cellulose is turned into carbon dioxide & water, releasing heat & light
  + *Endergonic*: reactions that yield products that are rich in potential energy. endergonic reaction starts out w/ reactant molecules that contain relatively little potential energy. Energy is absorbed from surroundings as reaction occurs, so products of endergonic reaction contain more chemical energy than reactants did
    - *Ex*. photosynthesis uses energy poor reactants CO2 & water, then using energy absorbed from sunlight to produce energy-rich sugar molecules
  + *Metabolism:* total of organism’s chemical reactions
    - *Metabolic pathway:* series of chemical reactions that either builds complex molecule or breaks down complex molecule into simpler compounds
    - *Energy Coupling:* use of energy released from exergonic reactions to drive essential endergonic reactions
  + How it relates to ATP:
    - The hydrolysis of ATP is exergonic
    - A cell couples this reaction to endergonic one by transferring phosphate group from ATP to some other molecule (phosphorylation)
      * *Chemical Work:* phosphorylation of reactants provides energy to drive endergonic synthesis of products
      * *Mechanical Work:* transfer of phosphate groups to special motor proteins in muscle cells causes proteins to change shape & pull on protein filaments, causing cells to contract
      * *Transport Work:* ATP drives active transport of solutes across membrane against their concentration gradient by phosphorylating transport proteins
    - Energy released in exergonic reactions is used to regenerate ATP from ADP (when phosphate group is removed) 🡪in endergonic process, phosphate group is bonded to ADP, & hydrolysis of ATP releases energy that drives endergonic reactions.