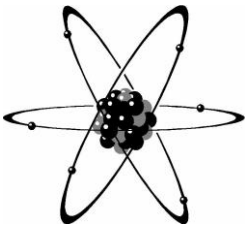
OPHS Biology Name: _____

Unit 2 (Biochemistry)

Topic 1: Atomic and Molecular Structure

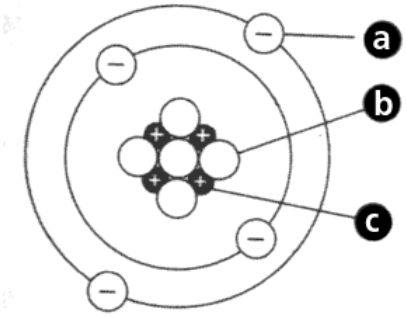


By the end of this topic, you should be able to…

- Label an atom and it's subatomic particles
- Identify the charge of each subatomic particle
- Differentiate between different types of bonds (covalent & ionic)
- Explain the similarities and differences between the following terms: atom, ion, element, compound, molecule
- List the six main elements in living things

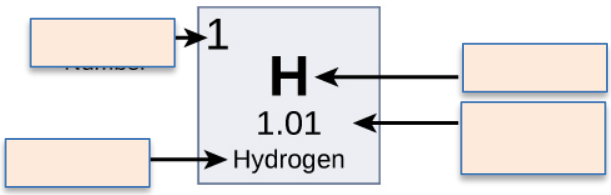
Atoms

- What is an atom?
  - Basic unit of _____
  - **Smallest** particle of an element that contains all properties of that element
- Subatomic Particles: While an atom is the smallest unit of matter, it is made of even smaller components (subatomic particles)
  - Proton: _____ charge (__); located in the _____ of atom
  - Neutron: _____ charge (__); in the _____ of atom
  - Electron: _____charge (__); surrounds _____ of atom
- Label the Following Atom:



Neutrons	Protons	Electrons
-Atoms of the same element may have different numbers of neutrons (In this case, we are looking at _____ of that element) -Isotope: each of two or more forms of the same element that contain _____ in their nuclei, and hence *differ in atomic mass* but not in chemical properties (in particular, a radioactive form of an element)	-Atoms of the same element MUST all have the same number of protons in the nucleus of the element -The number of protons is also equal to the _____ -The number of protons is balanced by the number of _____	-Electrons are negatively charged subatomic particles that surround the nucleus of an atom -Little to no mass (negligible, not included in atomic mass) -Travel at high speeds around the nucleus -Play a large role in chemical bonding

Periodic Table Information:



- Atomic number = # of protons
- Atomic mass = # of _____ plus # of _____ (add together everything found in the _____)
- Protons & neutrons each have a mass of 1 amu (_____)
- Mass of electrons is negligible, so we do not add that in

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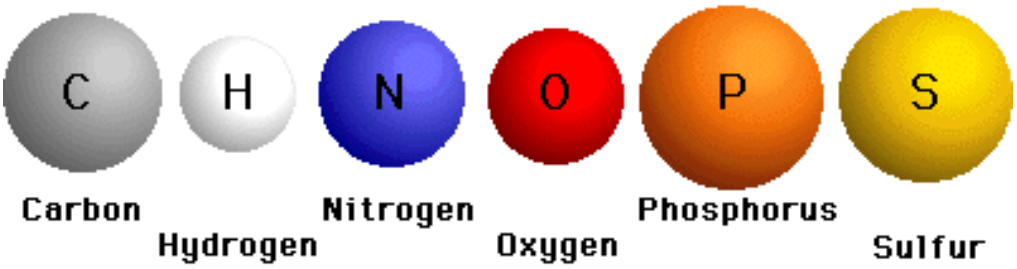
Elements

- 92 natural elements
- An element is composed of _____
- **Six** main elements in living things:

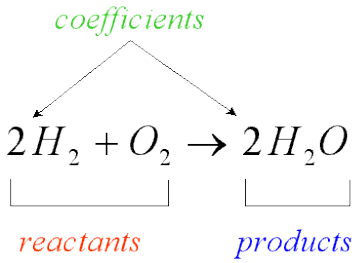


Chemical Compounds

- Atoms are the _____
- Elements are made of atoms of one type
- **Compounds** are formed by the _____
  _____
  - Compounds are chemically joined, so they differ from the elements that they are made of (H_2O is very different than hydrogen and oxygen on their own)
  - Chemical formulas are used to show the _____ and _____ of atoms of each element in the compound

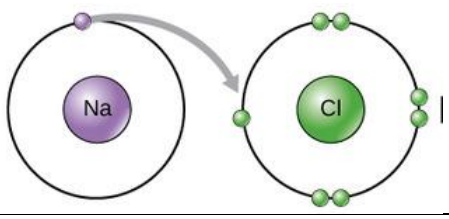
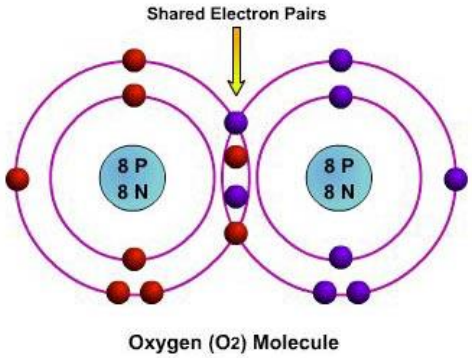
Chemical Formulas

- Subscript _____ a symbol tell the number of atoms of each element
- H_2O has 2 atoms of hydrogen & 1 atom of oxygen
- Coefficients _____ a formula tell the number of molecules
  - $3O_2$ represents 3 molecules of oxygen or (3x2) or 6 atoms of oxygen



Chemical Bonds

- Atoms in a compound are held together by chemical bonds
  - The electrons in the outermost shell that are used to form these bonds are called
    _____
- Types of bonds:

Ionic	Covalent
What happens to the electrons? • _____ What forms as a result? • _____ Oppositely charged *ions* are _____ to one another How are positively charged ions formed? • _____ How are negatively charged ions formed? • _____ 	-Two atoms combine by _____ electrons -_____ charge -Strength of bond depends on _____ _____ 

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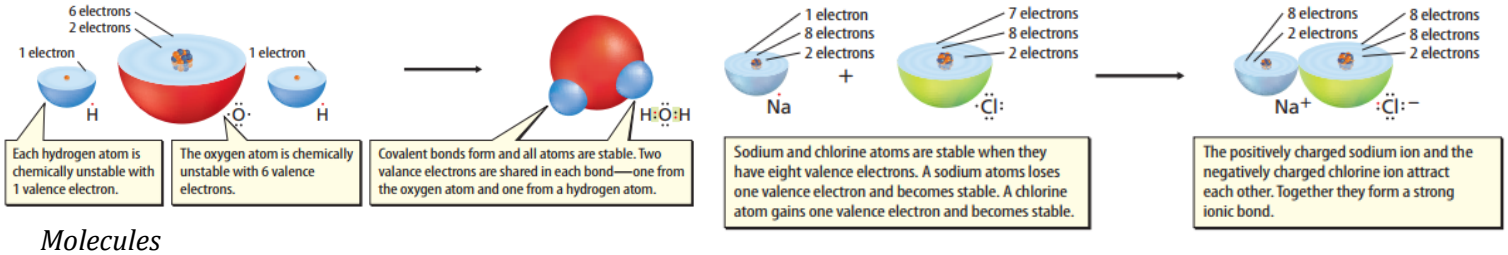


Molecules

- Atom – smallest unit of matter
- Element – made of one type of atom
- Compound – two or more elements chemically bonded together
- Molecule – _____ joined together chemically
    - All compounds are molecules, but not all molecules are compounds

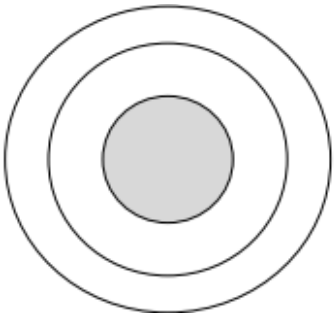
Van der waals Forces

- When molecules are close together, a slight attraction can develop between the oppositely charged regions of nearby molecules.

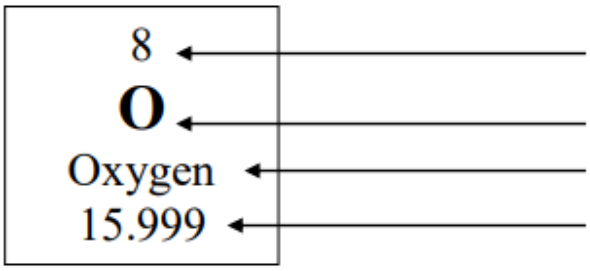
[[*Language Target for Topic 1: I can draw and label an atom, identifying the key subatomic particles and their charge; I can compare and contrast covalent and ionic bonds; I can list the six main elements in living things.*]]

Part 1:

1. Draw five protons in the nucleus of the atom. Label them with their charge.
2. Draw six neutrons in the nucleus of the atom.
3. Draw two electrons in the first energy level and label them with their charge.
4. Draw three electrons in the second energy level and label them with their charge.
5. What element is represented by the diagram? _____



6. Label the information provided in the periodic table.



7. What does the atomic number represent?

_____ or _____

8. What does the atomic mass represent?

_____ + _____

Part 2:

1. Define ionic bond and explain what an ion is: _____
    _____
    a. How does a positive ion form? _____
    b. How does a negative ion form? _____
2. Define covalent bond: _____
    _____

Part 3:

1. List the six main elements in living things: _____
    _____

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Unit 2 (Biochemistry)

Topic 2: Properties of Water

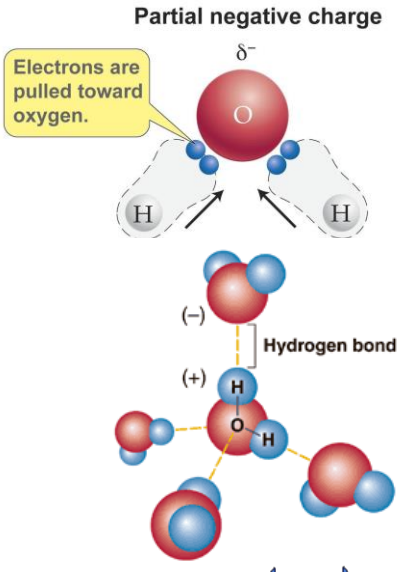
By the end of this topic, you should be able to…

- Explain what "water is polar" means
- Explain the importance of hydrogen bonds in water
- List the properties of water
- Discuss the pH scale and identify substances as acids, bases, or neutral

Properties of Water

- Water is not alive, but understanding water is essential
  - ~2/3 the mass of a cell is water
  - Most life-sustaining reactions take place in _____
- Water, H_2O, is a molecule made of _____ **covalently** bonded to _____

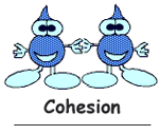
Polarity

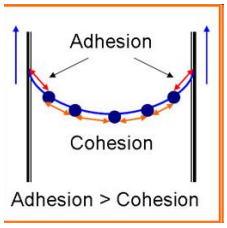


- Electrons are _____ distributed in a molecule of water
  - Leads to positive end and negative end (opposites attract!)
- The atom with more protons, _____ (8), pulls electrons closer to its nucleus
  - This makes oxygen slightly _____ & hydrogen slightly _____
- Molecules of water are attracted to one another and form hydrogen bonds
  - Opposites _____
  - Each molecule of water can make up to _____
    - Hydrogen bonds are _____

Adhesion & Cohesion

- **Adhesion**: attraction between _____ molecules (water to a _____)
- **Cohesion**: attraction between _____ molecules (water to _____)
  - Results in **surface tension** (measure of the _____ _____)
- Produces a _____, allowing insects to _____
- Cohesion (water sticking to water) and adhesion (water sticking to other substances) work together to form **capillary action**
  - Water _____

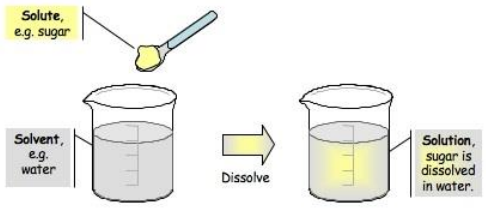




Real life example: water is absorbed by the roots of plants and travels upward!

Universal Solvent

- **Universal solvent**: water dissolves more substances than any other liquid
  - Again, because water is _____ and has hydrogen with _____ ends and oxygen with _____ ends, water _____ many other substances and is able to dissolve these substances it attracts
  - General rule: _____, so being polar, water dissolves other _____ substances
    - It cannot dissolve nonpolar substances, like oils!



- Solute: substance that is _____ (sugar)
- Solvent: substance that _____ (H_2O)
- Mixture: combination of substances in which individual substances retain their own properties (sand + sugar)
- Solution: mixture of 2+ substances in which the molecules of these substances are evenly distributed (sugar water)

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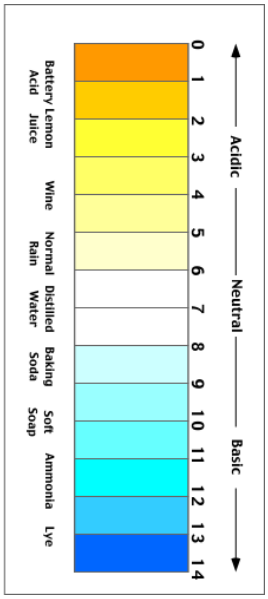
- Suspension: no dissolving occurs, but one substance separates into small pieces and remains suspended

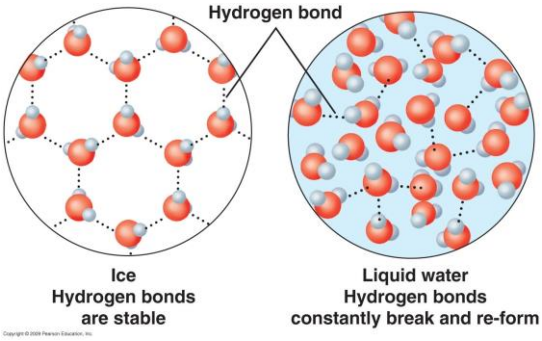
Pure Water has a pH of 7



- pH: measure of how _____ a solution is
  - Scale ranges from _____
- Acid: H+ (hydrogen ions) form in water; pH is _____
  - The _____ the pH (when under 7), the _____ the acid
- Base: OH- (hydroxide ions) form in water; pH is _____
  - The _____ the pH (when above 7), the _____ the base
- Neutral: pH is _____

Density of Water

- Water is _____ in its _____ form (ice) than its _____ form
  - The orientation of hydrogen bonds pushes the molecules to push further apart, lowering the density
  - Because ice is less dense, it _____ on liquid water
  - If water was most dense at the freezing point, then in winter the very cold water at the surface of lakes would sink, the lake could freeze from the bottom up, and all life in them would be killed. And, with water being such a good insulator (due to its heat capacity), some frozen lakes might not totally thaw in summer.



Heat Capacity/Specific Heat

- Water absorbs a lot of heat from the air without having a large temperature change
- Lakes and oceans often _____ air temperatures
- Water absorbs heat when it cools, which is why sweating helps us cool down
- It takes a lot of heat to change the temperature of water because the hydrogen bonds between the water need to be broken!

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[[*Language Target for Topic 2: I can relate the properties of oxygen and hydrogen to the polarity of water; I can explain how water's polarity and hydrogen bonding give it unique properties and differentiate between the listed properties of water; I can draw and label a pH scale with acid, base, and neutral.*]]

Part 1:

1. Draw and label a molecule of water. Explain how many atoms are in a single molecule of water and what bonds hold these atoms together, being sure to use the term polar in your response.

Part 2:

1. Explain how molecules of water stick together: _____
   _____
2. Choose three properties of water and illustrate/explain them:

Part 3:

1. Draw and label a pH scale, giving at least one example of an acid/base/neutral substance.

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Unit 2 (Biochemistry)

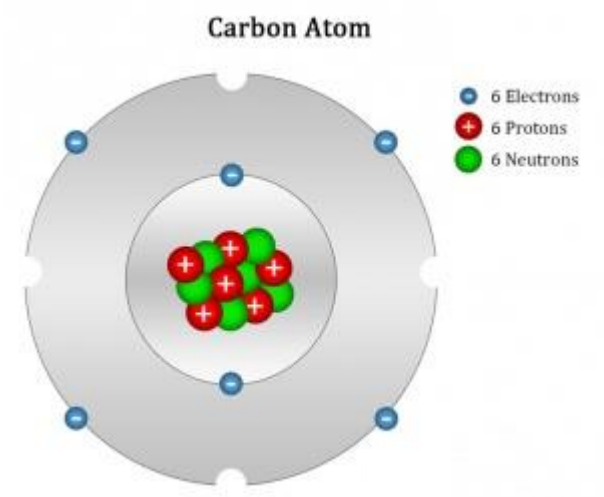
Topic 3: Macromolecules

By the end of this topic, you should be able to…

- Explain what the term "organic" means
- Define monomer and polymer and explain how polymers are made/broken
- Explain what happens to molecules during the processes of hydrolysis and dehydration synthesis
- Identify the monomer for each class of organic compounds
- Identify which class of organic compounds a compound falls into when given an image or function or elements used
- Explain the function of each of the four classes of organic compounds

Revisit: What are the six main elements in living things?

_____ _____
_____ _____
_____ _____

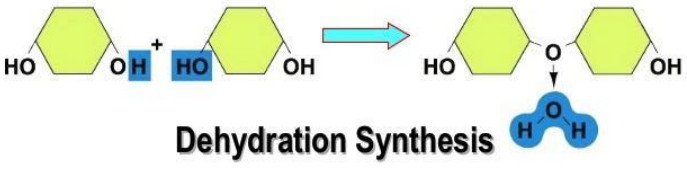


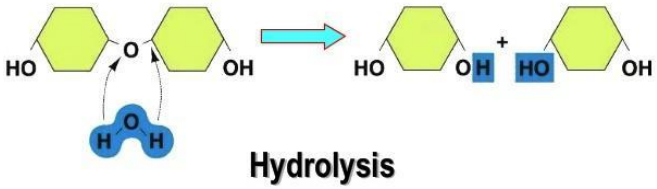
Carbon

- Carbon is the backbone of _____ compounds (macromolecules)
  - The term organic means contains _____
  - Organic chemistry is an entire field dedicated to studying compounds containing bonds between carbon atoms
- An atom of carbon contains _____ valence electrons
  - So, it is able to make up to four covalent bonds with other atoms!

Macromolecules

- Macro- _____
  - Macromolecules are large molecules with a backbone made of _____
  - Macromolecules are so large because they are made up of smaller units
    - Monomer: the _____ of a polymer (_____)
    - Polymer: _____ of repeating units (monomers)
    - Polymerization: process of linking monomers together to produce polymers
  - Dehydration Synthesis
    - Dehydrate – _____
    - Synthesis – to produce/make/combine
    - All together: this is the process by which monomers _____ to make a polymer. In the process, water is lost. One water molecule is lost for _____ joined to another.
  - Hydrolysis
    - Hydro – _____
    - Lysis – _____
    - All together: this is the process where water is _____ to _____ the bonds holding monomers together.





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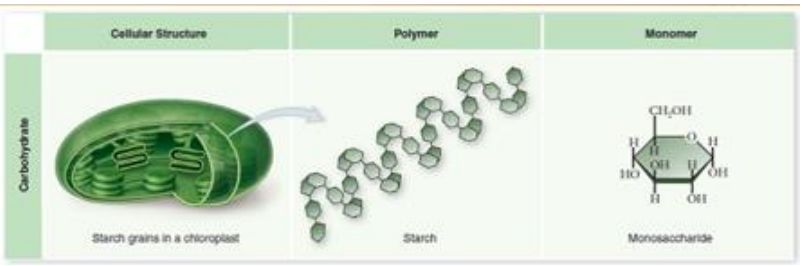
Unit 2 (Biochemistry)

ORGANIC COMPOUNDS: Macromolecules

Four classes: carbohydrates, lipids, nucleic acids, and proteins

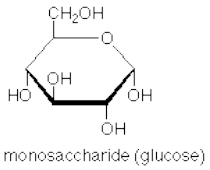
I. Carbohydrates

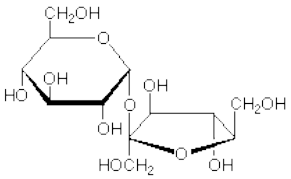


- Carbohydrates are _____
  - Carbo – _____
  - Hydrate – _____
    - So, carbohydrates are made of: carbon, hydrogen, and oxygen (1:2:1 ratio)
- Function: _____; maintain plant structure (_____)

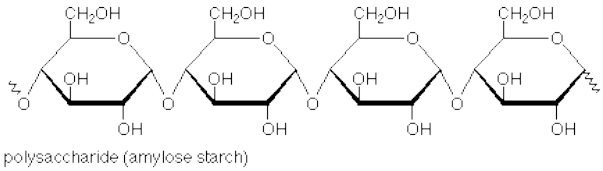
  *General rule: anything that ends in –_____ is a _____

  glucose… sucrose… galactose… lactose
- _____: **monomer** of carbohydrates; simple sugars (ie glucose)
  - Mono – _____
  - Saccharide - _____


monosaccharide (glucose)


disaccharide (sucrose)

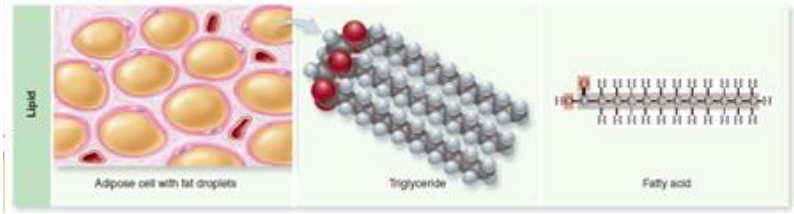
- Disaccharide: _____ monosaccharides bonded together (ie sucrose)
  - Di – _____
- Polysaccharide: carbohydrate polymer (many sugars joined together in a chain)
  - Importance of polysaccharides: store energy (short term)
  - Examples:
    - **Starch**: food storage in _____ (think potatoes!)
    - **Glycogen**: food storage in _____ (us!)
    - **Cellulose**: _____ in plants


polysaccharide (amylose starch)

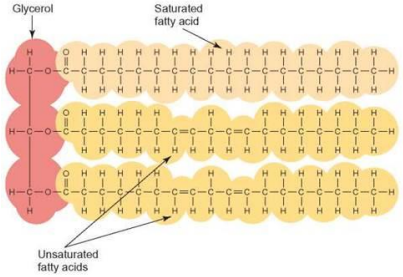
II. Lipids

- Lipids include _____
  - Elements: like carbohydrates, these are composed of carbon, hydrogen, and oxygen
    - There are very few oxygen, and there is not a set ratio like in carbs
  - Functions: _____, insulation, and protective coatings (think waxy layers of plants)
    - ***L*ipids: *L*ong term energy storage**

**Steroids often carry chemical messages*



- Unlike the other classes of organic compounds, lipids do not have a "true" **monomer**. However, the structure between lipids is fairly consistent:
  - _____
  - TRIGLYCERIDE!
- Saturated: _____ at room temperature (butter or coconut oil)
  - Only _____ bonds between the carbons on the fatty acid tails
    - "saturated" with _____ atoms
- Unsaturated: _____ at room temperature (vegetable or canola oil)
  - At least one _____ bond in the fatty acid chain
    - <u>Mono</u>unsaturated fat: only <u>one</u> double bond
    - <u>Poly</u>unsaturated fat: <u>2+</u> double bonds in structure



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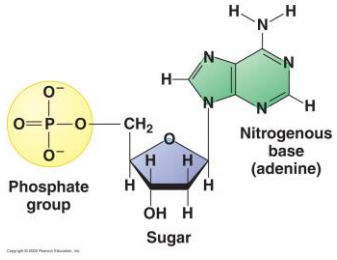
III. Nucleic Acids

- DNA and RNA are both types of nucleic acids
  - Elements: _____
    - Each nucleotide, or **monomer**, has a _____ _____
      - Remember, sugars contain CHO… add in the nitrogen base and P-group, and there you have the elements _____!
  - Functions: _____ and _____ genetic information (DNA- master code; RNA- carries code)
- _____ are the building blocks, or monomers, of all nucleic acids
  - 3 parts:
    - 5-carbon sugar (deoxyrib**ose** in DNA, rib**ose** in RNA)
    - Phosphate group (almost always represented using a sphere/circle)
    - Nitrogenous base (DNA – adenine, thymine, cytosine, guanine; RNA – uracil instead of thymine)

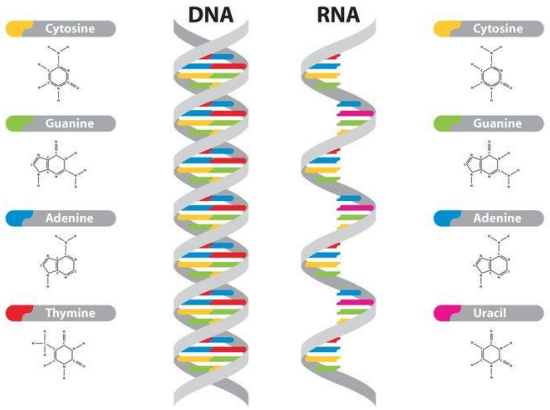


DNA

- _____ acid
- _____ of an organism's genetic code

RNA

- _____ acid
- Copy of DNA (able to leave nucleus)
- Plays major role in _____



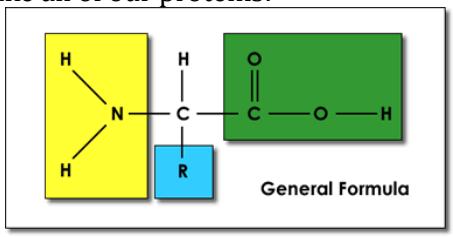
IV. Protein

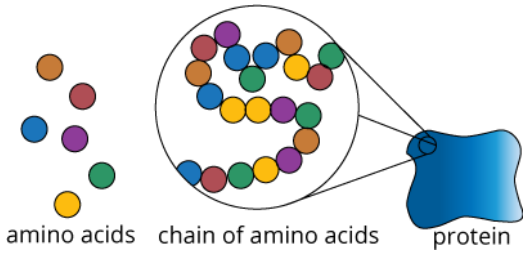
- Elements found in proteins include: CHNO and sometimes S
- Functions:
  1. _____ (hail, nails)
  2. _____ (hemoglobin)
  3. _____ (muscle fiber)
  4. _____ (antibodies)
  5. _____ (hormones and enzymes)

- _____ are the building blocks, or **monomers**, of proteins
  - There are _____ different amino acids that can be bonded together in many different ways to make all of our proteins!

Amino acids…

- Central Carbon
- Hydrogen Atom
- Amino Group
- Carboxyl Group
- R Group





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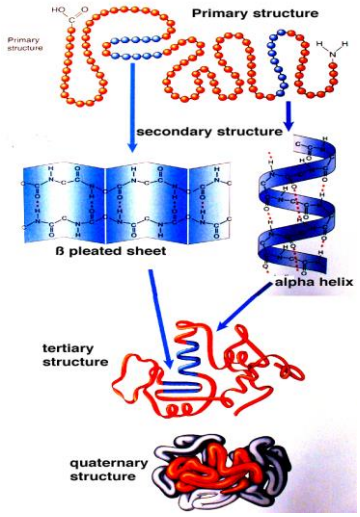
Unit 2 (Biochemistry)

Polypeptide: a chain of amino acids linked together (polymer)

- Amino acids are connected through _____ bonds
- Proteins are made of polypeptides folded into complex structures

Four levels of protein structure:

1. Primary
2. Secondary
3. Tertiary
4. Quaternary



[[*Language Target for Topic 3: I can identify an organic compound as one containing carbon; I can create a table identifying the function, structure, polymers, and monomers for each of the four classes of macromolecules.*]]

Part 1:

1. Define the term "organic," and provide examples of organic compounds: Organic means containing _____. The four classes of organic compounds are _____, _____, _____, and _____.

Part 2: Complete the table:

	Function	**Structure**	**Polymer**	**Monomer**
Carbohydrate				
Lipid				
Nucleic Acid				
Protein				

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Topic 4: Enzymes

By the end of this topic, students should be able to…

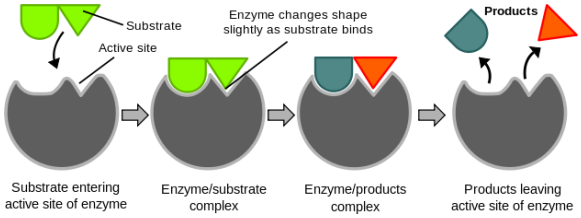
- Identify the components of a chemical reaction (products and reactants/substrates)
- Construct a graph detailing enzyme reaction data
- Describe the function of an enzyme
- Explain the importance of shapes in active sites on an enzyme
- Explain how enzymes speed up chemical reactions (act as biological catalysts)

Why Study Chemistry in Biology?

- In order to understand how an organism functions, we need to understand the reactions that take place in that organism.
  - Growth, response to stimuli, sensing, taking medicine to control regulation… all of this is chemistry!

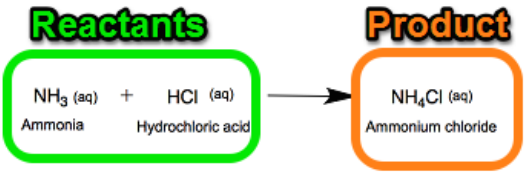
Enzymes

- Enzymes are _____ that act as biological _____. (often end in –_____)
  - Living things produce enzymes to act as catalysts
  - Catalysts _____ _____
    - Catalysts _____ during a reaction… so they can be used over & over again *unless* their _____



Chemical Reactions

- To understand how enzymes speed up chemical reactions, we need to know what chemical reactions are.
  - Chemical reaction: process that changes _____ into _____ by _____ in the reactants and _____ in the products

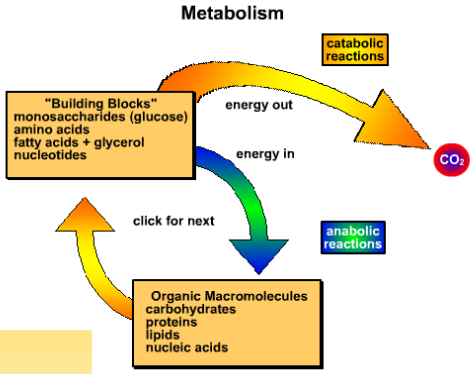


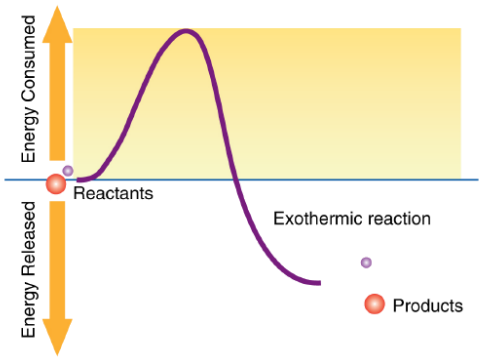
- Reactants: what you _____
- Products: what you _____

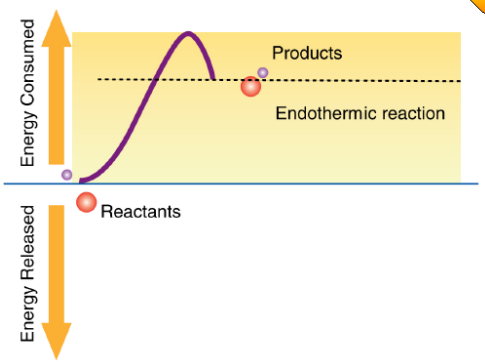
**In chemical reactions, you can either put reactants together or break them apart. Your product can be one final product or many individual pieces.*

Energy in Reactions

- _____ is the sum of all chemical reactions that take place in a living thing
  - Metabolic pathways: product from one reaction is the _____ (reactant) for the next
- Catabolism: chemical reactions where complex molecules are _____ into simpler molecules
  - Usually _____ to drive these reactions
- Anabolism: chemical reactions where simpler molecules are _____ to form more complex molecules
  - Usually _____ energy
- Exothermic: energy _____ (digestion)
- Endothermic: energy _____ (synthesis)





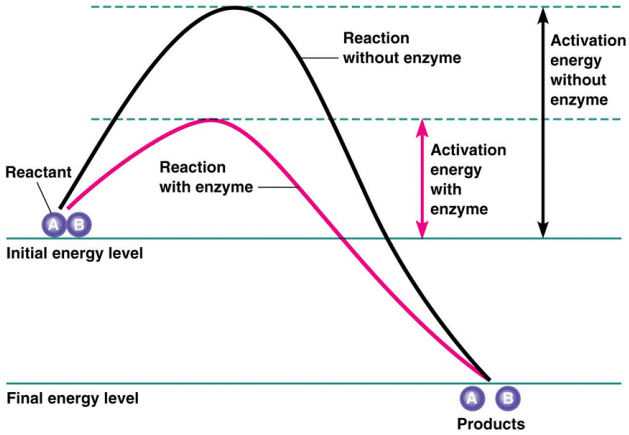


OPHS Biology Name: _____

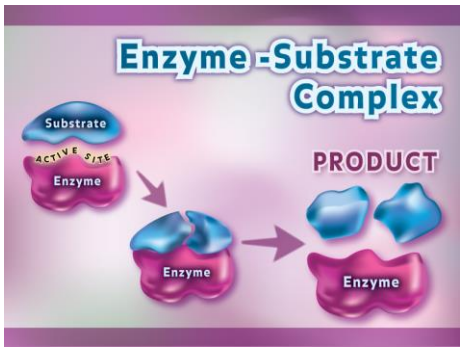
Unit 2 (Biochemistry)

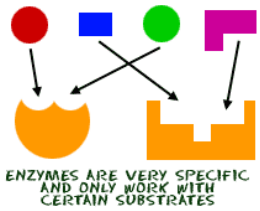
Role of Enzymes

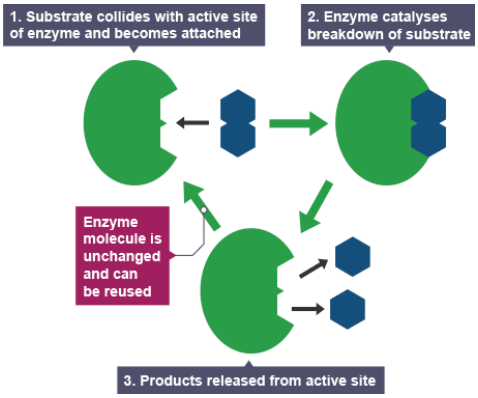
- The role of enzymes is to _____!
  - Activation energy: the amount of energy required to _____ a reaction
- In biology, we like to say "_____ _____."
  - So, the form (shape) of an enzyme impacts its role.
  - Enzymes are _____. They only work with certain substrates. These substrates must _____ into the _____ _____ of the enzyme.



- Each enzyme has a place called the "active site." This is where the substrate(s) (reactants) bind to the enzyme.
- Once the substrate(s) has connected itself with the enzyme, the reaction takes place.
- The substrate(s) _____ into the active site of the enzyme (lock & key model or induced fit).
  - **Enzyme-Substrate Complex!**
- Once the reaction is complete, the enzyme releases the product(s) of the reaction.

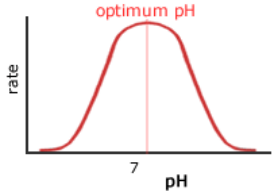


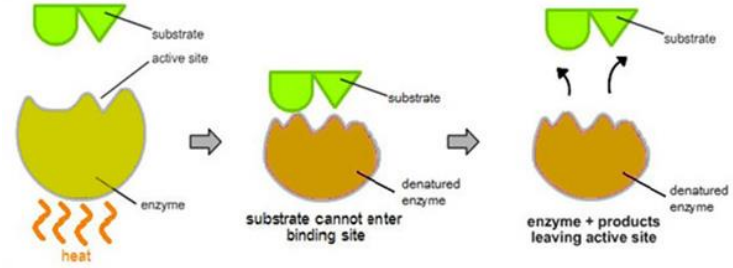




What happens if enzymes change shape?

- We call this a "_____"
enzyme/protein.
- When the shape changes, the substrate(s) will _____ in the active site, so the enzyme will no longer function. The organism needs to get rid of this enzyme.
- Enzymes work best in certain _____ ranges. The best pH or temperature is said to be "_____."
- Changing this optimum environment too much leads to enzyme _____.





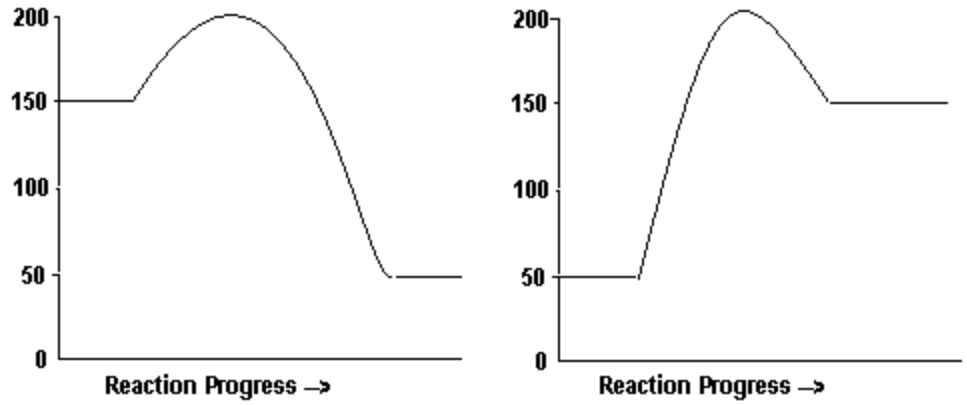
OPHS Biology Name: _____

Unit 2 (Biochemistry)

[[*Language Target for Topic 4: I can construct an appropriate graph for enzyme reaction data and explain the role of enzymes on the reaction rates; I can explain the importance of enzymes and their role in reactions to a peer.*]]

Part 1:

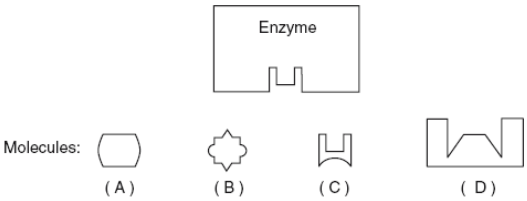
1. On the graph below, identify the products, reactants, activation energy, and amount of energy released/absorbed. Calculate the Activation Energy of each and identify it as endo- or exo- thermic.



On each graph above, sketch what the curve would look like if an enzyme was used.

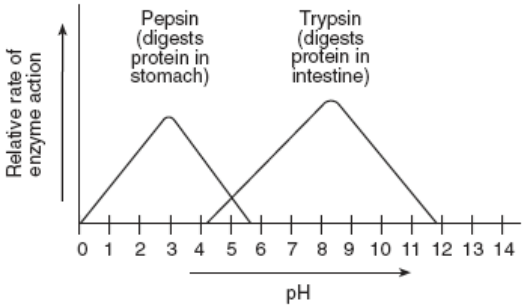
Part 2:

1. The enzyme would most likely affect reactions involving which of the molecules pictured?



2. How does an enzyme work?

3. What is the optimal pH for both enzymes?



Pepsin:

Trypsin:

Definition of optimal:

4. Compare, using the pepsin and trypsin graph above, the rate of the pepsin-catalyzed reaction at pH of 3 with the rate of the trypsin-catalyzed reaction at pH of 3.