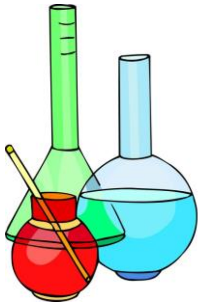


The Chemistry of Biology

Life depends on chemistry. Living things are composed of chemical compounds. If order to understand biology, one must first understand the chemistry of life.

I. The Nature of Matter

A. The Atom

1. An atom is the:

2. The atom is the:

3. Atoms are composed of subatomic particles:

4. Protons and neutrons have about the same mass and together form the nucleus of the atom.
5. Electrons have a mass of about $1/1840^{th}$ the mass of a proton and are in constant motion in the space surrounding the nucleus.

6. The subatomic particles have charges:

B. Elements

1. An element is:

2. There are more than 100 known elements, but only about 20-24 are commonly found in living organisms.

C. Compounds

1. A compound is:

2. For example: The formula of water is H_2O. There are 2 hydrogen atoms bonded to one oxygen. This definite ratio is always present in water.

II. Chemical Bonds

A. The atoms that compose compounds are held together by ________________________.

B. Bond formation always involves the ____________ that surround the nucleus of each atom.

C. There are two main types of bonds:

D. Ionic Bonds

1. An ionic bond is formed when one or more electrons are:

2. When electrons are gained or lost, ________ are formed. Ions are atoms that have either:

3. If an atom loses electrons, it will then have a ____________ charge. If an atom gains electrons, it will then have a __________ charge.

4. An ionic bond is formed when:

5. For example: Sodium tends to lose an electron and becomes a Na^+ ion. Chlorine tends to gain one electron and becomes a Cl^- ion. These two ions are then attracted to one another because they have opposite charges. The compound NaCl is formed.

6. The attraction between _______________________________________ is an ionic bond.

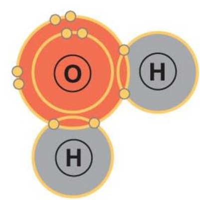
E. Covalent Bonds

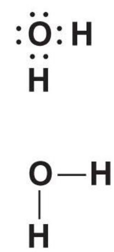
1. Sometimes electrons are ____________ between atoms instead of being transferred.
2. When electrons are shared between two atoms, the shared electron spends time traveling around the nuclei of both atoms.
3. A covalent bond is formed when:

4. For example: In a water molecule, each hydrogen atom shares electrons with the oxygen atom.

The shared electrons spend part of the time traveling around the ______________ nucleus and part of the time traveling around the ____________ nucleus.

When atoms are joined together by covalent bonds, _________________ are formed. A molecule is the smallest unit of a compound.





F. Polar Molecules

1. When covalent bonds are formed between atoms of different elements, there are different degrees of:

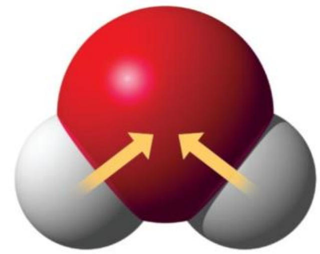
2. In covalent bonds formed between atoms of different elements, the electrons are not:

3. Some atoms have a ______________________ for electrons than do other atoms. As a result, the electrons are not ______________________________.

4. The atom around which the electrons spend the most time will have a ____________________ charge, and the atom around which the electrons spend the least time will have a _________________________ charge.

5. Polar Covalent Bonds:

6. For example: In a water molecule, oxygen has a ________________________ for the shared electrons. The shared electrons spend more time around the ____________ atom, so the oxygen atom has a __________________________charge.

   The shared electrons spend less time around the _______________ atom, so the hydrogen atom has a _____________________charge.

   A water molecule is:

7. Nonpolar Covalent Bond: The electrons are shared _____________________. These bonds exist between identical atoms such as H_2, Cl_2, O_2, and N_2.

III. Water – Can't Have Life Without It!!

A. The Polarity of Water

1. In a water molecule, an oxygen atom has a much ________________________ for electrons than does the hydrogen atom. At any given time, there is a greater probability of finding the shared electrons near the _____________ atom than near the _______________ atom.

2. As a result, the oxygen end of the molecule has a slight _____________ charge and the hydrogen end of the molecule has a slight _____________ charge.

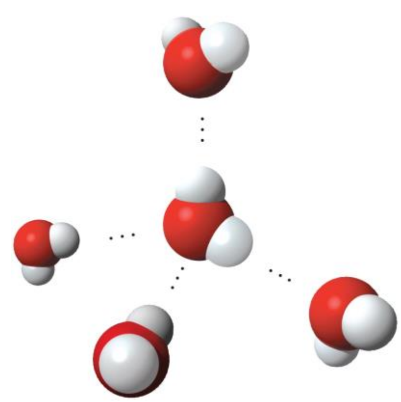
3. A molecule that is positive at one end and negative at the other end is called a _______________________.

4. A water molecule is polar because there is an uneven distribution of electrons between the oxygen and hydrogen atoms.

B. Hydrogen Bonding

1. Water molecules stick together because:

   This force of attraction forms _________________________.



2. In the picture to the right, the attraction between:

3. At this point we are only interested in the attraction of hydrogen bonding between water molecules, but hydrogen bonds can form in other places, as we will see throughout this year.

4. A single water molecule can form up to _______ hydrogen bonds with other water molecules are the same time. This is responsible or many of the unusual properties found in water.

5. Cohesion is:

   Water molecules stick to one another because of ______________.

6. Adhesion is:

   When water sticks to other substances beside itself, it does so because of ________________.

C. Solutions and Suspensions

1. Mixture:

2. There are two kinds of mixtures. Mixtures may be either:
   a) Homogeneous:

   b) Heterogeneous:

3. Solution: A solution is a __________________ mixture. The parts of the solution are evenly mixed.

4. The two parts of a solution are:
   a) Solute:

   b) Solvent:

   c) For example: Salt crystals will dissolve when placed in water. Salt is the __________ and water is the ______________.

5. Because water is so polar, it makes it the greatest solvent on Earth. Many substances will dissolve into water.

6. Suspensions
   a) Suspension:

   b) Some materials do not dissolve in water, but separate into pieces so small that they do not _______________. These small pieces remain _____________ and are "_____________" in the solution.
   c) Example: Your blood is a suspension.

E. Water Makes Life on Earth Possible

Without water, life on Earth would not be possible. Here are the reasons why life on Earth is dependent on water.

1. Water is _____________. This means that water molecules like to ____________________. At a wide range of temperatures, this sticking together of water molecules makes water _________________. If the temperature gets too high, ________________ bonds are broken and water molecules will ____.

2. Water _________________ temperatures on Earth. Water is a very good "heat bank" because it can _________________________ a large amount of heat with only a slight change in its own _____________________. Life could not exist in bodies of water if there were drastic changes in temperature. Temperatures on land are stabilized by bodies of water. Large bodies of water ____________ heat from the sun during the day, ______________ landmasses. Large bodies of water _____________ heat at night ______________ the landmasses. This stabilizes temperatures on land as well as in the water.

3. Water is the solvent of life. Water is able to:

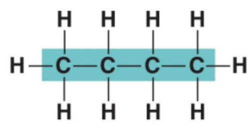
F. Acids, Bases, and pH

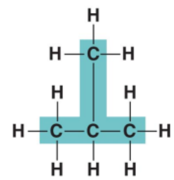
1. The pH scale
   a) The pH scale is a measurement system used to indicate the concentration of _______ ions in a solution.
   b) The pH scales ranges from __________________.
   c) A pH of 7 is a ____________ solution. This is neither acidic nor basic. Pure water has a pH of 7.
   d) Solutions with a pH below 7 are considered ______________.
   e) Solutions with a pH above 7 are considered ______________.

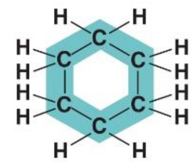
2. Acids
   a) Acid:
   b) Acidic solutions:
   c) Acids have a pH of ________.
   d) Examples include: lemon juice, tomato juice, carbonated drinks, vinegar

3. Bases
   a) Base:
   b) Basic solutions:
   c) Bases have a pH of _____________.
   d) Examples include: ammonia, soaps, bleach, sodium bicarbonate

4. Buffers
    a) The pH of most human cells should generally be between ______________.
    b) If the pH gets too high or too low, it affects the chemical reactions that take place within cells.
    c) Cells must be able to control their pH.
    d) Buffers are substances produced by cells that:

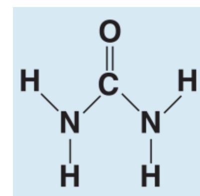






IV. Carbon Compounds

A. Organic Compounds
   1.



   2. Characteristics of carbon include:
      a) Carbon forms:

      b) Carbon can form bonds with other _______________________as well as a variety of _______________________ such as ________________________ ____.

      c) Carbon can form:

      Carbon can form _______________________.

B. Macromolecules
   1. Many of the molecules in living cells are so _____________ that they are known as __________________________. This means "________________________".

   2. Macromolecules are made from____.
   3. The four groups of organic compounds found in living things are:
      a)

      b)

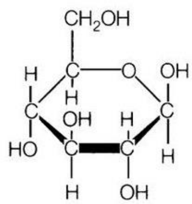
      c)

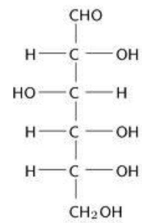
      d)

V. Carbohydrates

A. Characteristics of Carbohydrates

1. These compounds are made up of ______________________________________ in a ratio of ________________.





2. Examples of carbohydrates are:

3. The carbohydrates are known as the "quick energy" foods because:

4. There are two main functions of carbohydrates:
   a)

   b)

5. The smaller molecules that make up the carbohydrates are _________________________________.

B. The Sugars

1. Carbohydrates are classified according to:

2. ____________________________ contain only ______ molecule of sugar.

3. ____________________________ are composed of ____ molecules of sugar bonded together.

4. ____________________________ are composed of ________ molecules of sugar bonded together.

C. Three Common Polysaccharides

1. Starch
   a) Only found in _____________.
   b) This is the way that plants ____
   c) Many, many molecules of ______________ are bonded together to form _____________.

2. Glycogen
   a) Only found in ________________.
   b) This is the way that animals ___________________________________.
   c) The liver bonds together many, many molecules of _____________ to form _______________.

3. Cellulose
   a) Cellulose is the

   b) It gives ___________ to the plant ________________.

   c) Cellulose is the major component of wood and paper.

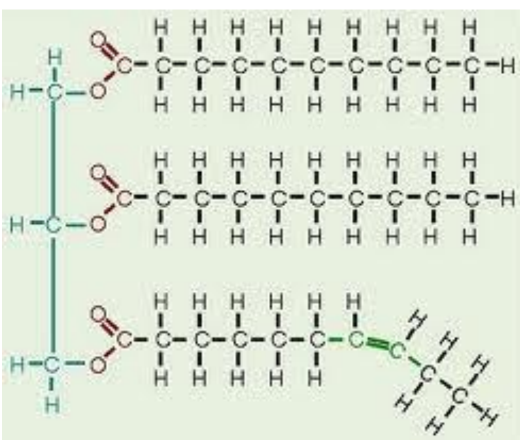
VI. Lipids

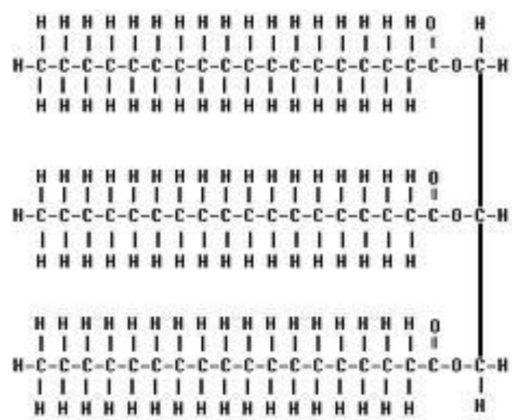
A. Examples of lipids are ______________________________________.

B. These compounds are generally not _______________ in water.

C. Lipids contain the elements _______________________________________ but not in the__________ ratio seen in the ____________________.

D. There are two building blocks of lipids: __________________________________.





Tristearin

1. A lipid has:

2. Circle and label the glycerol molecule in each of the above drawings.
3. Label the three fatty acid tails in each drawing.

4. If a fatty acid tail has at least one ______________________________, it is said to be an _____________________ fat.

5. If a fatty acid tail has no _________________________________, it is said to be a ________________________ fat.

6. Which of these drawings is a saturated fat?

   Which is an unsaturated fat?

7. Saturated fats tend to be __________ at room temperature. Examples are:

8. Unsaturated fats tend to be __________ at room temperature. Examples are:

9. Saturated fats clog up your arteries and veins. Please do not eat too many of these!!!!

E. Uses of Lipids
   1.

   2.

   3.

   4.

VII. Nucleic Acids

A. Nucleic acids are macromolecules containing the elements:

B. There are two kinds of nucleic acids: _______________________.

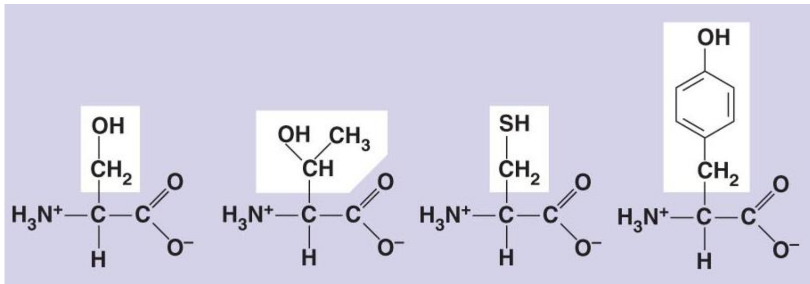
C. The building blocks of the nucleic acids are ______________________.

D. Nucleic acids ____.

VIII. Proteins

A. Proteins are macromolecules that contain:

B. The building blocks of proteins are ________________. There are ________________________.



C. Each amino acid has four parts. Label these groups on the drawing above.

1.

2.

3.

4.

D. There are many, many uses for proteins
1. enzymes
2. hormones
3. transport proteins such as hemoglobin
4. contractile proteins such as in muscle tissue
5. antibodies
6. membrane proteins
7. structural proteins such as bones and muscles

IX. Chemical Reactions and Enzymes

A. Life depends upon the ____________________________ that occur within the cell. Living organisms undergo thousands of chemical reactions as part of their life processes.

B. These reactions are important to the ____ ____.

C. The reactions of a cell involve both the ______________ of molecules, and the __________________________ of molecules. The role of enzymes is to greatly enhance the ______________ of these reactions.

X. Chemical Reactions

A. A chemical reaction is a process that: ____

____.

A chemical reaction occurs when chemical bonds between atoms are _____________ or _____________, resulting in the production of ____.

1. Reactants: ____

2. Products: ____

B. Chemical reactions always involve changes in the ________________________ that join atoms together in compounds.

C. Examples:

1.

2.

XI. Energy in Reactions

A. Whenever chemical bonds form or are broken, energy will be __________________________. The forming and breaking of bonds involves changes in energy.

B. Some chemical reactions ______________ energy. Other chemical reactions _____________ energy.

C. Living organisms carry out a great variety of chemical reactions. Many of these reactions release energy, while many others absorb energy.

Regardless of whether energy is released or absorbed by the reaction, starting the chemical reaction ____.

D. In order for the reaction's ______________ to form, existing ______________________ in the reactants must first be _____________. This will require _______________.

XII. Activation Energy

A. Activation Energy:

1. ____

2. ____

3. ____

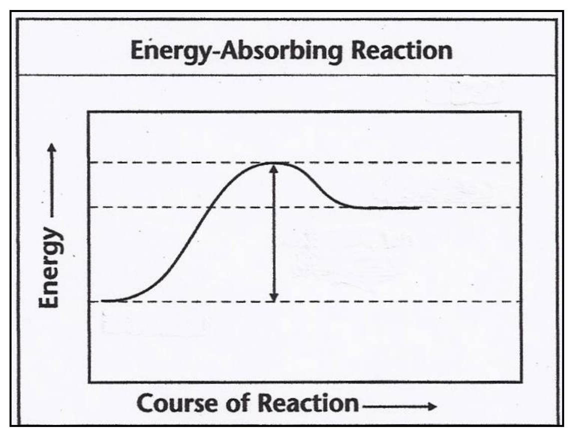
B. Energy-Absorbing Reactions

1. ____

2. The bonds of the ______________ molecules will have to be broken. New bonds will be formed during the formation of the ______________.

3. The activation energy is: ______________________

   ____
   ____
   ____



4. An example of an energy absorbing reaction in living cells is the process of ______________.

   The reactants are ____________________________. These reactants have ________ energy than the product, which is ____________.

   The energy that is absorbed by the reactants is stored in the bonds forming the glucose molecules.

C. Energy-Releasing Reactions

1. ____

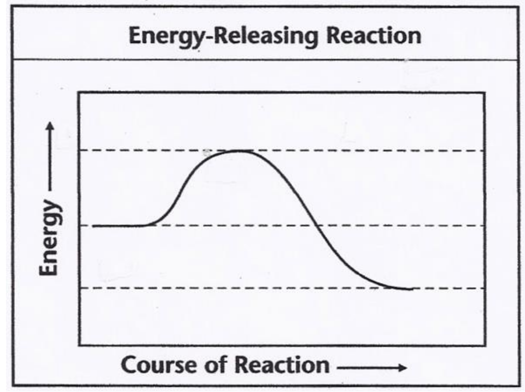
2. ____

   ____

3. The activation energy is the amount of energy that must be: ____

   ____

   ____



4. An example of an energy releasing reaction in living cells is the process of ______________________. The reactants are _________________________________.

   It will require a small _________________ of energy (activation energy) in order to break the bonds of glucose.
   However, once the reaction begins, more energy will be released than was required to start the reaction.

D. This activation energy is usually in the form of ________ that the reactant molecules absorb from the ___________________.

The bonds of the reactants break only when the molecules have: _________________________

____.

E. Activation energy is the amount of energy needed to push the reactants over an energy barrier or "hill" so that the "downhill" part of the reaction can begin.

F. Many of the chemical reactions of a cell proceed too ______________ to be of use to the cell. The activation energy required for these reactions is simply too _________. The cell must have a way to make these reactions occur __________ and at lower ___________________.

How is this done??? _______________!!

XIII. Enzymes – What are they?

A. Enzymes are ____.

1. A catalyst is: ____
   ____.

2. Enzymes are ______________________ that act as
   ____.

3. Enzymes are essential for the functioning of any cell.

B. Enzymes _______________________ the chemical _________________ that take place inside ______________.

1. Many of the reactions inside cells take place: ____.

2. Enzymes: ____.

3. Lowering the activation energy makes the reaction take place much _____________ and at a
   ____.

4. Without enzymes, cells would soon ______. The chemical reactions required in living cells would take place too
   ____.

5. Example: Sucrose will spontaneously break down into ______________ and ________________, but it will take ____________ to do so. If a small amount of the enzyme ________________ is added to the solution, all of the sucrose will be broken down within ________________.

6. Enzymes are so _________________ for their substrate that they can only catalyze ___________________________________. In the above example, sucrase speeds up the breakdown of sucrose, and it can do no other job.

7. Because enzymes are so specific, their name is usually derived from __________________________
   _____________________________________.

   Example: What does the enzyme lactase do? ____

   ____

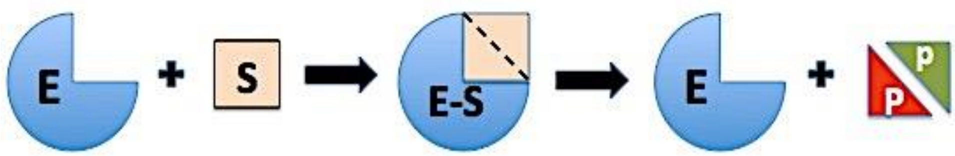
   ____

C. Comparison of Enzymes and Catalysts

Enzymes	Catalysts

XIV. How Enzymes Work

A. This is a simple equation illustrating how an enzyme works:



1. Substrate: ____

2. Enzymes have ____

3. The pocket or indentation is called the _____________________.

4. For the enzyme to speed up the reaction, there must be a ___________________________________ between the enzyme and its _____________________ molecule. The fit is so precise that the active site and substrates are often compared to a "_________________________."

5. Intermolecular forces bind the enzyme and substrate together to form the ______________________________. They remain bound together until the reaction reaches completion.

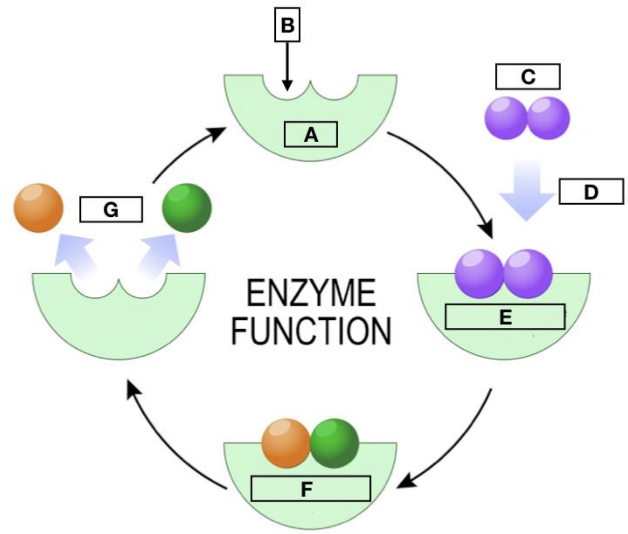
6. During the enzyme-substrate complex, the bonds ______________________________

____.

7. At the end of the reaction, the ____________________ are released.

8. The enzyme is free to start the process again.

9. Diagram of an enzyme-catalyzed reaction.



A : ____________________

B: ____________________

C: ____________________

D: ______________________________

____

E: ______________________________

F: ______________________________

____

____

____

G: ______________________________

____

____

____

10. The joining together of the enzyme and the substrate causes a slight change in the enzyme's ____________. This shape change allows the enzyme to conform to the shape of the substrate and probably ______________________________ in the substrate, which is one way that enzymes reduce ________________________.

B. Let's summarize the facts about enzymes:

1. Enzymes are ____________ that speed up the ____________________ of the cell. An enzyme may accelerate a reaction by making it happen 10,000,000,000 times faster! This means that a reaction that would take 1,500 years to complete without the enzyme can be completed in just 5 seconds with the enzyme.

2. Enzymes do not ____. They simply speed up the reactions that _______________________________________.

3. Enzymes make reactions take place ____________ and at _____________________________________.

4. Without enzymes the reactions of the cell would proceed ____________________ that the cell would _________.

5. Enzymes are very ____________________. They can only carry out ____________________, but they do that one job extremely well.

6. Enzymes are never ____________________ in the reaction. They can be used ___________________________ again.

7. 2000 enzymes are now known. Each is responsible for a specific chemical reaction.

8. The shape of the enzyme is so _______________ that only one shaped _________________ can fit.

9. A specific enzyme is required for each reaction in a cell.

10. Enzymes catalyze both the ____ of the same reaction.

C. Factors that affect enzyme functioning

1. Anything that changes the ______________ of the enzyme will affect _____________________________ ____.

2. One factor that affects enzyme functioning is ______________________________.

3. Every enzyme has an ____________________________________ at which it will function the __________.

4. For most enzymes, the optimum temperature is _________________ Celsius.

5. If the temperature exceeds the optimum, the enzyme may become _______________________. The bonds that determine the shape of the enzyme are altered, changing ____.

6. A __________________________ enzyme has lost its particular shape. It no longer has a _______________________________ to its _____________________. When an enzyme is denatured, it cannot ____ in the chemical reaction.

7. Another factor that affects enzyme activity is ________. Every enzyme has an optimum pH at which it functions the best. A pH value outside of this range can cause _______________________ _______________________________.

8. As you might expect, most enzymes function best in a pH range of ____________. Exceptions to this are the enzymes found in the ____________________. These enzymes function best at a pH level of around __________________. At a neutral pH, these stomach enzymes would be denatured.