Unit 2: Cellular Chemistry, Structure, and Physiology

Module 2: Cellular Chemistry

NC Essential Standard:
- 1.2.1 Explain how cells use buffers to regulate cell pH
- 4.1.1 Compare the structure and functions of the major biological molecules as related to the survival of living organisms
- 4.1.3 Explain how enzymes are catalysts for biological reactions

Why do athletes consume protein shakes / powders after a workout?

- PROTEIN DOES NOT GIVE YOU ENERGY!!! *This is why it is consumed AFTER a workout, not before!*
- Protein is the basic building material for living things – that includes *muscles*.
- After a workout, there are tiny microscopic tears in the muscles… a meal rich in protein will help rebuild those muscles!

I. Where can I find chemicals in my body?

A. A **chemical** is a substance that is made up of elements/molecules and used in a chemical reaction. Chemicals made up of more than one type of element are called **compounds**.

B. Living things are made of two main types of chemical compounds:

1. **Inorganic**: _____ _____. Water (made of the elements hydrogen and oxygen) is the most important inorganic compound for life:

Chemical formula of water:

Inorganic because…

i. _____ is the most abundant compound in a cell (and organism). Most organisms are 60% - 90% water by weight.

ii. Most chemical reactions occur in water because it provides an _____ Ex. transport of molecules in the cell

2. **Organic**: _____ _____. There are four main types:

The "Core Four" organic compounds:

1.

2.

3.

4.

a. _____ (made of carbon, hydrogen, oxygen)
Ex. Provide energy source for respiration (glucose)

b. _____ (made of carbon, hydrogen, oxygen)
Ex. Insulate and protect organs in the body (fats)

c. _____ (made of carbon, hydrogen, oxygen, nitrogen and phosphorus)
Ex. Allow traits to be passed from parent to child (DNA)

d. _____ (made of carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus)
Ex. Provide specifically shaped molecules that can carry other molecules (hemoglobin carries oxygen)

C. Scientists can _____ of the different chemicals, such as carbohydrates, using **indicators**. For example, iodine changes to a blue-black color in the presences of starch.

D. The six essential elements (CHNOPS) are essential to life because they help _____.

a. The elements make up essential organic and inorganic compounds. _____ _____ in organisms (see examples above).

b. Hydrogen is also donated or accepted by weak acid-base pairs to _____ like cells and blood. These weak acid-base pairs are called **buffers**.

HOW does a buffer help maintain homeostasis?

i. When a cell's pH drops (becomes more acidic), the buffers in the cell "accept" the hydrogen ions which reverses the pH change

ii. When a cell's pH rises (becomes more basic), the buffers in the cell "donate" hydrogen ions

iii. In a cell, acid is being produced as the cell respires. To maintain the pH, a cell must use buffers to counteract the acid.

iv. Different cells or areas of the organism need different pH levels to perform. _____ _____. Ex: The stomach of a human maintains a pH of 1.5-3.5, but the blood of a human must remain between 6.8 and 7.8. This requires different buffers in the stomach and blood.

Check Yourself!

1. What are the six essential elements?
2. What is the most important inorganic compound to life?
3. What are the four major organic compounds?

4. How are the six essential elements important to homeostasis (two ways)?
5. What is a buffer?

II. How does synthesis provide important organic macromolecules using six essential elements?

A. Carbohydrates

Example of monosaccharide:

Examples of polysaccarides:

1. Carbohydrates are organic compounds made of _____ _____ in a 1:2:1 ratio. The subunit (**monomer**) is called a **monosaccharide**. Many _____ forming a larger carbohydrate chain called a **polysaccharide**.
   a. In plants the monosaccharide called **glucose** (_____) bonds with other glucose molecules again and again to

form _____. The plant can use starch as food (like the "white" of a potato) and cellulose to build the stem and leaves.

b. In animals excess glucose bonds together to form a compound (similar to starch) called _____ which is used for short-term energy storage. Glycogen is found in the liver and muscles.

2. Functions of carbohydrates

a. _____ when carbohydrates are digested. This is because glucose is used for cellular respiration.

i. Monosaccharides (simple sugars) provide an _____ energy source.

ii. Starch and glycogen are considered _____ energy storages because these chemicals can be broken down over a period of minutes, hours or days to provide glucose for the cell.

b. Some carbohydrates are very stable and can be used for _____ in the cell and body (cellulose in the cell wall of plant cells).

c. Carbohydrate chains on the surface of cell membranes are used as _____ (like name tags).

3 functions of carbohydrates:

1.

2.

3.

B. Lipids

1. There are several types of lipids, but all contain subunits of _____ made of carbon, hydrogen, and oxygen. These combine to make a very large molecule (macromolecule). Unlike a carbohydrate the smaller units do not link together to form a chemical chain, but combine in the _____.

a. _____can be saturated (usually solid at room temperature) or unsaturated (usually liquid).

Drawing of lipid subunit:

b. **Phospholipids** also contain a phosphate group and make up most of the _____.

c. **Steroids** are lipid rings and help regulate the organism through _____ (act as hormones).

2. Functions of lipids

a. Because of the numerous bonds and the way the body stores lipids, they can be used as very _____ _____.

Ex. Bears accumulate a layer of fat before winter (when food will be less available)

b. Fats stored in the body act as _____ for internal organs.

c. Some _____ are composed of lipids (steroids).

3 functions of lipids:

1.

2.

3.

Check Yourself!

1. What three elements make up both carbohydrates and lipids?

2. What function do both carbohydrates and lipids provide?

3. What is the subunit of both starch and glycogen?

4. What are the two subunits found in all lipids?

C. Nucleic Acids

1. **Nucleotides** are compounds made up of _____ _____. Many nucleotides bond together to make up a long chain called a **nucleic acid**. There are two basic types of nucleic acids:

a. _____is a double chain of nucleotides found in all cells.

b. _____ is a single chain of nucleotides that provides the structures needed for the cell to make proteins.

2. Functions of nucleic acids
   a. DNA _____. Genes determine traits, such as hair color. Genes are passed from parent to offspring.
   b. DNA _____ by controlling the production of proteins. Hormones and other cellular signals determine what genes are used in the cell.
   c. RNA is used in the _____.

3 Functions of Nucleic Acids:

1.

2.

3.

D. Proteins

1. All six essential elements may be used in the production of small subunits called **amino acids**. There are _____ _____, each with a specific side chain of chemicals. Amino acids bond to other amino acids to form a long chain called a protein. These chains of amino acids fold into a particular shape. The _____ _____. If a protein **denatures** (loses its shape) it cannot function.
   a. _____ is a protein shaped to hold oxygen for transport through the bloodstream.
   b. A group of proteins called _____ are shaped to fit and react with specific molecules.
2. Functions of proteins – _____
   a. Some proteins, called _____, absorb and reflect light. They also create color by reflecting light.
      Ex. Chlorophyll absorbs light to gather energy for Photosynthesis, and reflects the color green.
   b. Some proteins are constructed by cells to bind with and inactivate foreign particles in the body. These are called _____.

What happens when a protein "denatures"?

The MAIN function of protein is….

Some specific types of proteins:
1.
2.
3.
4.

c. Proteins may form structures in an organism – such as _____ (a protein) found in hair and nails.

d. Some proteins are used for _____ through the cell membrane or in the bloodstream (ex. hemoglobin)

e. Some proteins are used for _____ between cells. These may be hormones (insulin) or neurotransmitters. **Insulin** is secreted by the pancreas and is required by the cell of the body in order for them to remove and use glucose from the blood. Insulin can be used to treat diabetes.

f. **Enzymes** (a special class of protein) act to _____ _____, helping to maintain homeostasis.

Check Yourself!

1. What is the subunit of a nucleic acid?
2. What is the function of DNA?
3. What is the subunit of proteins?
4. What determines the function of a protein?
5. Which protein carries oxygen?
6. Name three functions of proteins.

III. Why are enzymes necessary for life?

A. Enzymes help maintain homeostasis

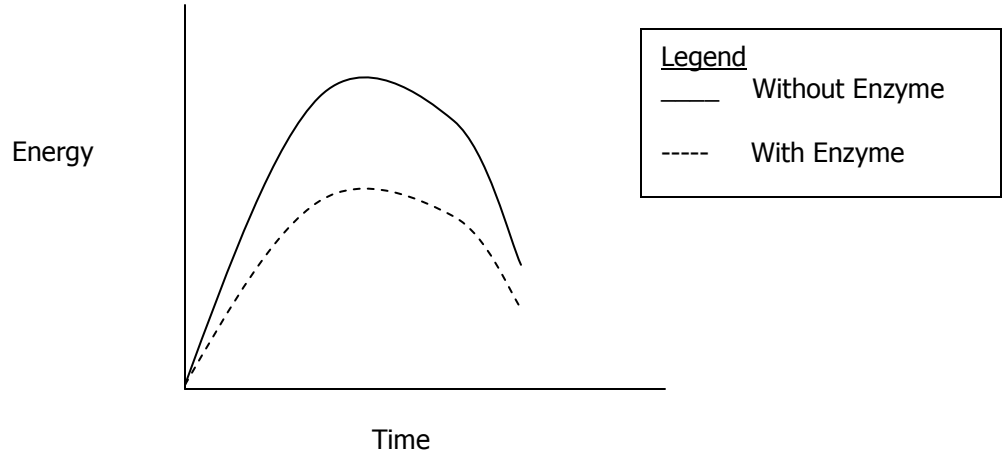
1. **Metabolism** (chemical reactions) requires certain conditions to occur. Enzymes regulate metabolism, allowing life to continue. _____, making an enzyme a **biological catalyst**.

The main job of enzymes:

2. Metabolism (each reaction) has a small range of temperature and pH at which it can proceed. _____ _____. This is called **activation energy**. Enzymes allow reactions to occur at lower activation energy (body temperature).

Reaction vs. Energy

Explanation of graph:



B. The structure of an enzyme determines its function

1. Enzymes are usually _____. Proteins have a definite 3-D structure based on how the amino acid chains fold.
   a. On the enzyme, there is a _____ _____. This place is called the **active site**. The target molecule/chemical is the **substrate**.
   b. If the enzyme's active site changes shape too much, the _____. An enzyme may change shape if it is **denatured** by a change in temperature, pH, or salinity. This means the enzyme will not be able to speed up the reaction.
2. Enzymes mediate (help) chemical reactions using a specific chemical pathway (series of steps).
   a. The enzyme _____ with the substrate.

Simple picture of an enzyme and substrate (label active site):

Enzymes and substrates are like a …

b. The enzyme and substrate fit together at the active site like a _____.

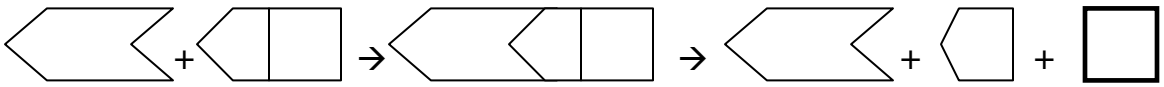
c. The enzyme _____.

   i. It may help break the substrate apart by stressing bonds.

   ii. It may hold two (or more) substrates together closely so the two parts interact.

d. The enzyme and the substrate (now product) separate.

Enzyme-Mediated Pathway



Enzyme + Substrate → Enzyme-Substrate Complex → Enzyme + Product A + Product B

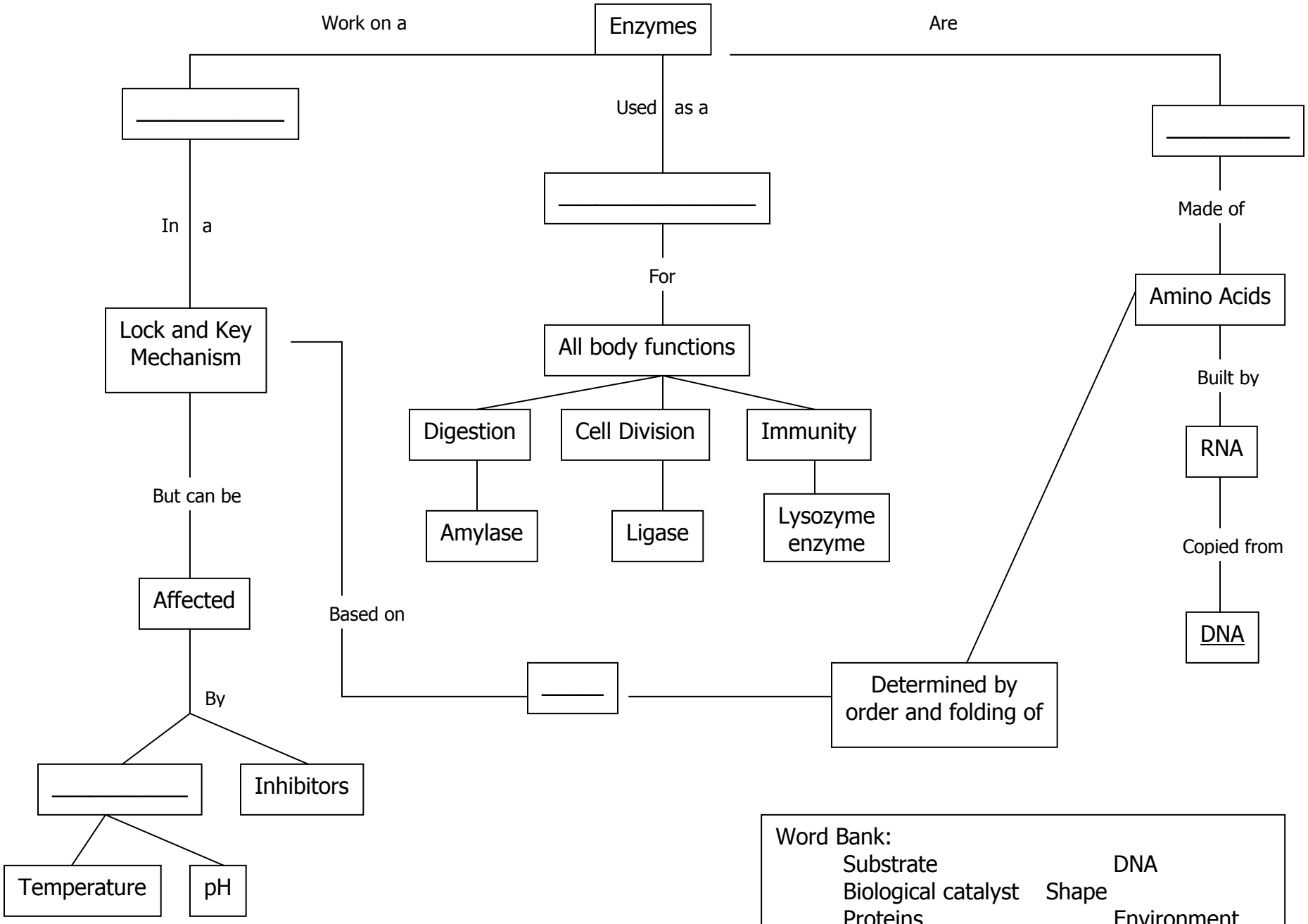
C. Enzymes have distinguishing characteristics

1. Enzymes are _____. This means enzymes will catalyze only one specific reaction because only certain substrates fit due to the shape of the active site.
2. Enzymes are _____. Notice in the diagram above that the enzyme did not change shape or split. This means it can now fit with another substrate or set of substrates and repeat its role in speeding up the reaction.

Watch It!

Check Yourself!

1. What do enzymes lower, allowing reactions to occur at body temperature?
2. What organic compound are most enzymes?
3. What is the name of the target chemical on which the enzyme works?
4. Is the active site located on the enzyme or the substrate?
5. Name two characteristics of enzymes.

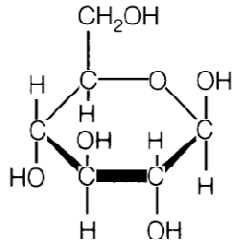


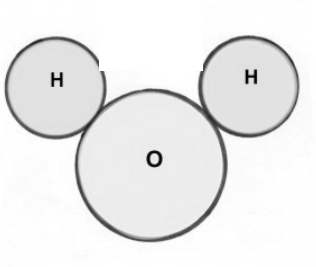
Word Bank:

Substrate		DNA
Biological catalyst	Shape	
Proteins		Environment

Unit 2 / Module 2
Problem-Solving Set

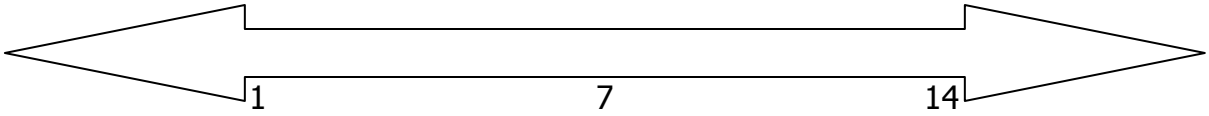
For each of the following chemical structures, determine if the structure is organic or inorganic. Write your answer on the line below the structure.

1. 

2. 

_____ _____

3. On the arrow below:
   - Label the pH that is neutral
   - Indicate the pH numbers that are acids
   - Indicate the pH numbers that are bases

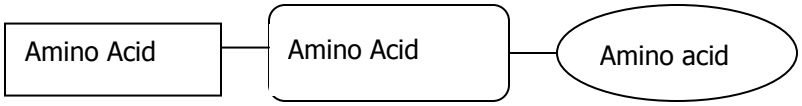


4. When a person has "heartburn" (also know as acid reflux), they may take medication such as Tums®, or Alka Seltzer®. Explain how this makes the person feel better, using the words "neutralize" and "buffer".

5. Complete the following table:

Organic Molecule	**Elements**	**Subunit**	**Functions/Jobs**
Carbohydrates			
Lipids			
Nucleic Acids			
Proteins			

6. Using the subunits below, identify which organic macromolecule is shown:



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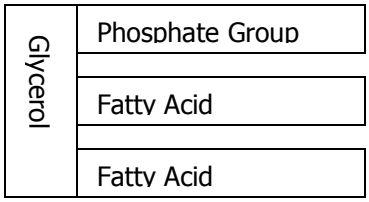

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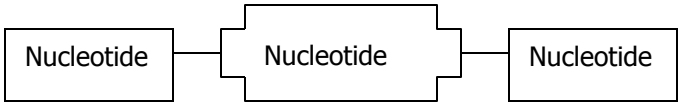

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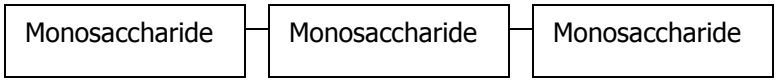


_____

For the problems below (7-10), determine which organic molecule would be the best choice. Each type of molecule will be used only once.

7. Julie has a track meet after school and she wants to eat a lunch that will provide energy, but isn't high in fat. What organic molecule should be the primary ingredient of her lunch?

   _____

8. Raul is studying birds that live in arctic regions and swim on the surface of the waters to capture fish. Due to the extremely cold temperatures of these regions and the birds' food gathering behavior, what organic molecule will most likely make up a large percentage of the birds' body composition?

   _____

9. Sardania is studying a disease in rats. She notices that the rats lack the ability to produce antibodies, have low muscle mass, and have a very inefficient digestive system. What molecule is likely deficient in these rats?

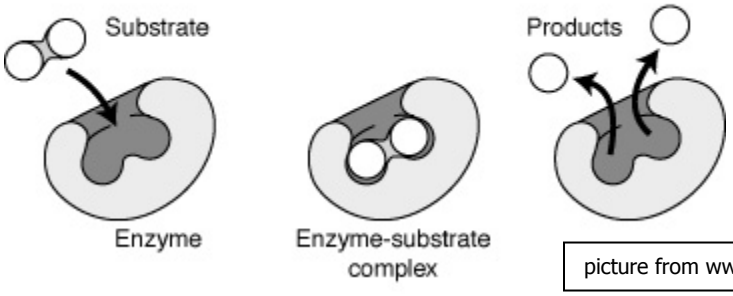
   _____

10. Brianna is doing a research project on the Romanov royal family of Russia. She notices that hemophila, a disease in which the blood does not clot properly, appears in many generations of the family. What organic molecule is the most likely cause of the <u>inheritance</u> of this disease within the family?

    _____

Use the diagram to answer questions 11 - 14 :

Mechanism of enzyme activity



picture from www.accessexcellence.org

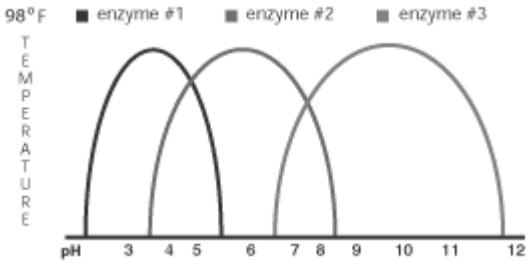
11. Color the diagram using the key below:
    - Enzyme = Blue
    - Substrate = Green
    - Product = Orange
    - Active site = Red

12. Put the following steps in order by placing a number in the blank.
    _____ The substrate and enzyme collide.
    _____ The enzyme releases the products.
    _____ The substrate and enzyme bind together.

13. Substrate B is shaped like a diamond (◇) Would this substrate react with the enzyme in the diagram? Explain. _____; _____
    _____

14. Compare <u>and</u> contrast the substrate(s) and product(s).

Use the following graph to answer questions 15 – 18.



Graph from www.thermadix.net

15. In what pH range does Enzyme #1 work? _____
16. Which enzyme works best at a pH of 6? _____
17. Which two enzymes are active at a pH of 5? _____ and _____
18. Which enzyme works best in a basic solution? _____

19. Defend the following statement, "If the enzyme denatures, the chemical reaction will slow down."

For questions 20-25, use the clues and blanks to determine the word.

20. Allows digestion to occur quickly at body temperature
    ◯ n __ y ◯ __

21. Type of organic molecule that makes the answer to #20
    __ r ◯ ◯ __ i __

22. A chemical that speeds up chemical reactions
    c ◯ __ __ ◯ y __ __

23. The chemical which is changed into the product
    ◯ u ◯ __ __ r __ __ __

24. Other than pH and salinity, a factor that can denature a protein
    t __ ◯ __ __ r __ __ __ __ __

25. The place on an enzyme that actually bonds to the substrate
    a __ __ ◯ __ e s __ __ __

26. Unscramble the letters circled in questions 20-25 to find the mystery word! Your clue is … "All the chemical reactions in an organism"

    __ __ __ __ __ __ __ __ __ __