Introduction to the Butler Biology Handbook

Hello!
We are delighted to share our work with you and hope the Biology Student Handbook will become a useful classroom tool or resource for you!
We, the authors, developed the first version of this handbook in 2000 as a solution to the problem of decreased instructional time when the school district began block scheduling. Our goal was to find a way to share information with students in a condensed and organized fashion, preserving valuable time for essential labs, activities, and independent work. The result of many hours of research, writing, classroom use, stress, coffee, late-night revelations, and yearly revisions is what you have before you. We designed the handbook using our years of experience in the classroom, the most current state standards, and recent educational research. Below is a chart outlining some of the classroom issues the use of the handbook as a classroom tool addresses, a brief explanation of how the handbook addresses these issues, and credit to the supporting research:

Obstacles	**Handbook**	**Research**
Student Behavior	Brisk instruction Active student involvement Provide correct model	Heward, 2003 Heward, 1994 Miller et al, 2003
Attention / Focus	Short "chunks" Active Responses Videos	Heward, 2003
Absences	Allows students access to material to "keep up" if not in class	Wagstaff, Combs, & Jarvis, 2000
Student Reading Skills	Summary Frames Linguistic / Nonlinguistic	Meyer and Freedle, 1984 Nye, Crooks, Powlie, & Tripp, 1984
Student Organization	Teacher-prepared notes / correct model	Marzano et al., 2001

We feel the handbook offers great flexibility in its use. Our school has chosen to provide a copy for each student, but it could also be used for individual modules, remediation, or as a general teacher resource.
We beg you to remember this is a copyrighted work written using our personal time (outside of CMS paid time), and respectfully ask that you not modify the work for use (you can copy it for your students all you like!). In short, we are ordinary people and hard-working teachers who are offering this to you without charge with one heartfelt plea – use it as much or as little as you would like, but without violating copyright (and without passing it along to other school systems, as we are in the process of putting it on the market).
A few other important notes about the handbook:

- **Pre-assessments** at the beginning of each module address research-based student misconceptions, as well as the misconceptions we see each year.
- **Vocabulary** terms are in bold print.
- The **summary prompts** in the margins are designed to require students to interact with the text and summarize important information, while offering guidance for students who struggle with critical thinking.
- **QR codes** have been embedded to allow students to use a "smart" device to link to videos about important concepts or to self-check answers at the end of each section. This can be done at home or in class.
- The "**Check Yourself**!" sections consist of level 1, recall questions only.
- The **recycle** symbol has been used throughout the text to direct students' attention to "recycled content" (content they have previously been exposed to in a previous module)
- **Concept maps** for each module provide a directed, non-linguistic representation of an over-arching concept.
- **Problem-solving sets** include application questions and are designed to help prepare students for assessments on the material.

Thank you so much for taking the time to read this introduction and for considering the use of our work. If you have **further questions** about anything pertaining to the Biology Student Handbook, **to be added to our community for new activities and updates**, please email one of us at:

biologyhandbook@gmail.com

Sincerely,
Shari Mudd and Jeni Day

Unit 1: The Nature of Biology

Module 1: How to Define Life

NC Essential Standard:
- Science as Inquiry
- 2.1.2 Analyze how various organisms accomplish life functions

STOP!

True or False …What do you think?

1. Science is a collection of facts.
2. There is a single scientific method that all scientists follow.
3. Scientific requires the application of imagination to devise a hypothesis.
4. Scientific conclusions are replicable.
5. Plants and fungus are not living, animals are living.
6. Respiration means breathing, so plants don't respire.
7. All living things have organs.
8. Growth and development are not the same.
9. All living things share certain characteristics.

I. How do you design an experiment?

Your friend is always trying to make money. He says, "I think if we grow some flowers under red light, the flowers will be red and we can sell them for Valentine's." How could you design an experiment to test this idea?

IV:

DV:

A. Problem/Purpose

1. The question the lab will answer
2. Identifies the independent and dependent variables
   a. **Independent variable** – the factor the scientist changes from group to group
   b. **Dependent variable** – the factor the scientist measures to see the effect of the independent variable

B. Research/Background Information

1. Lets the reader learn about the topic
2. Helps the scientist develop an educated hypothesis

C. Hypothesis

1. An educated prediction
2. Can be tested, proven false, and agrees with research

D. Procedure/Experiment

1. Steps must be precise and detailed
2. Has at least one **control group**
   a. Normal conditions or absence of independent variable
   b. Used for comparison
3. Experimental group(s) have only one changing variable (which is the independent variable)

E. Observations/Data

1. Must be objective.
   a. Good Example: The bacterial colony is yellow.
   b. Bad Example: The bacterial colony is nasty.
2. Use measurements whenever possible.
   a. Good Example: There are 50 bacterial colonies
   b. Bad Example: There are a whole bunch of colonies.
3. Do not draw conclusions in the data section of the report.
   a. Good Example: There are bacteria and fungal colonies in the shoe section.
   b. Bad Example: The shoe was really dirty and so it was the most contaminated and grew a lot of stuff.
4. Should be organized.
   a. May use a graph, table, or drawing(s).
   b. Always include units of measurement and a title.

F. Analysis/Conclusions

1. Answers the purpose question.
2. Accepts or rejects the hypothesis.
3. Explains what can be inferred from the data.

Six Steps of the Scientific Method:
1.

2.

3.

4.

5.

6

Watch It!

II. How do we know it is "good science"?

A. Scientific knowledge must be shared, which allows other scientists to repeat and verify the work of others (peer review).

B. Scientific knowledge is tentative.

1. **Theories** are the most logical explanation based on current evidence, become stronger as more evidence is gathered, and give us a basis for prediction.
2. **Laws** are universal generalizations that are virtually unchanging.

Check Yourself!

1. Which step of the scientific method is used to develop a hypothesis?

2. Which step is an educated prediction about the outcome of the experiment?

3. In the experiment, "The effect of nicotine on the heart rate of a cat?" …

a. the independent variable is _____

b. the dependent variable is _____

c. the control group would most likely be _____

III. How do you know something is alive ?

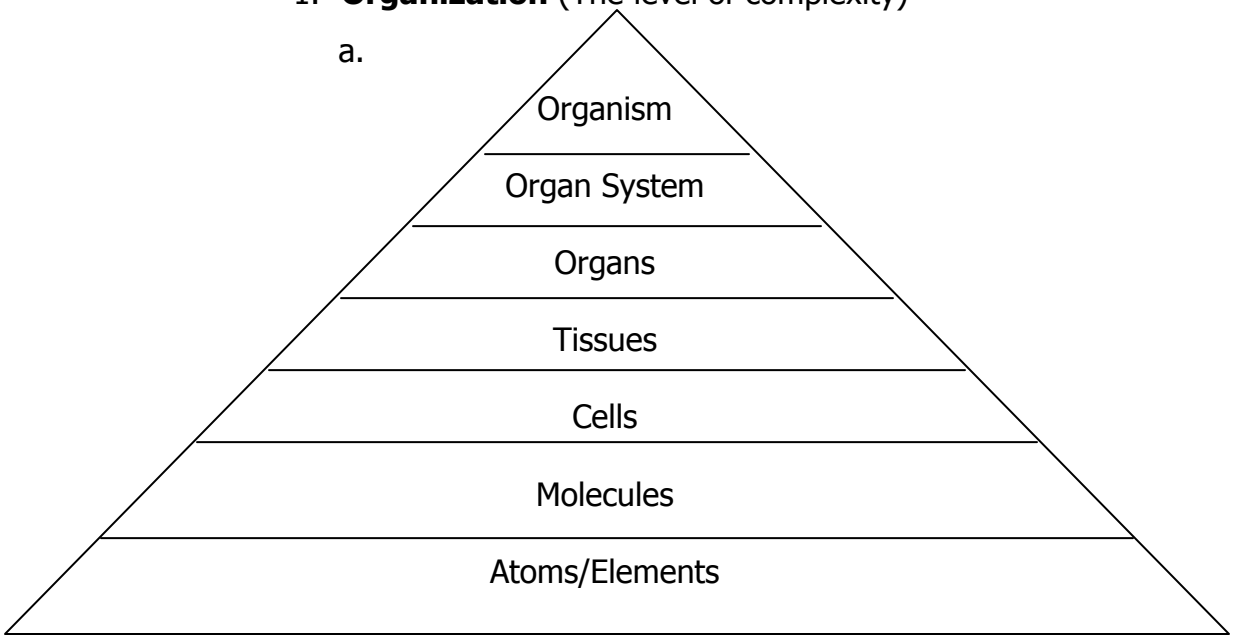
A. Biology means the study of (-ology) all life (bio-) and includes many branches.

B. Biologists organize living things into **kingdoms**. There are currently six kingdoms.

Kingdom	**Example**
Archaebacteria	Extremophile bacteria
Eubacteria	Typical bacteria
Protista	Seaweed, Amoeba, Slime Mold
Fungi	Yeast, Mushrooms
Plantae	Moss, Fern, Holly, Oak tree
Animalia	Worms, Fish, Birds, Frogs, Humans

C. Characteristics of life and Life Processes

1. **Organization** (The level of complexity)
   a.



   b. All living things need six essential elements (atoms): Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus, Sulfur (CHNOPS)
   c. All living things are made of cells.
      i. One-celled organism – unicellular
      ii. Many-celled organism - multicellular

2. Energy Use

Synthesis means …

Visual:

   a. Organisms need energy constantly to build molecules (**synthesis**) and cells and to break down (digest**)** substances (such as breaking down food for **nutrition**)
   b. Organisms must **transport** nutrients to be used in cellular **respiration** to produce energy.
   c. An organism's chemical reactions are called its **metabolism**.

3. Reproduction

   a. Organisms must replace themselves so the entire species will survive.

b. May be asexual (only one individual contributes genetic material) or sexual (two individuals contribute genes).

4. Growth and Development

a. **Growth** – to increase in size. Increases the number of cells of a multicellular organism.

b. **Development** – change that takes place in structure and function of an organism during its life cycle. Example: Embryo becomes a fetus

5. Respond to Stimuli

a. A quick, non-permanent change

b. Stimulus – anything that causes an organism to react. Example – A loud noise (stimulus) causes your dog to run under the bed (response).

6. Adjust to Environment

a. **Homeostasis** - the **regulation** of an organism's internal environment to maintain conditions for life Ex: Getting rid of wastes by **excretion**

b. An **adaptation** is an inherited structure, behavior, or internal process that enables organisms to better survive an environment. Ex: Gills on a fish

Life Processes:
(use bold terms)
S-

T-

E-

R-

N-

G-

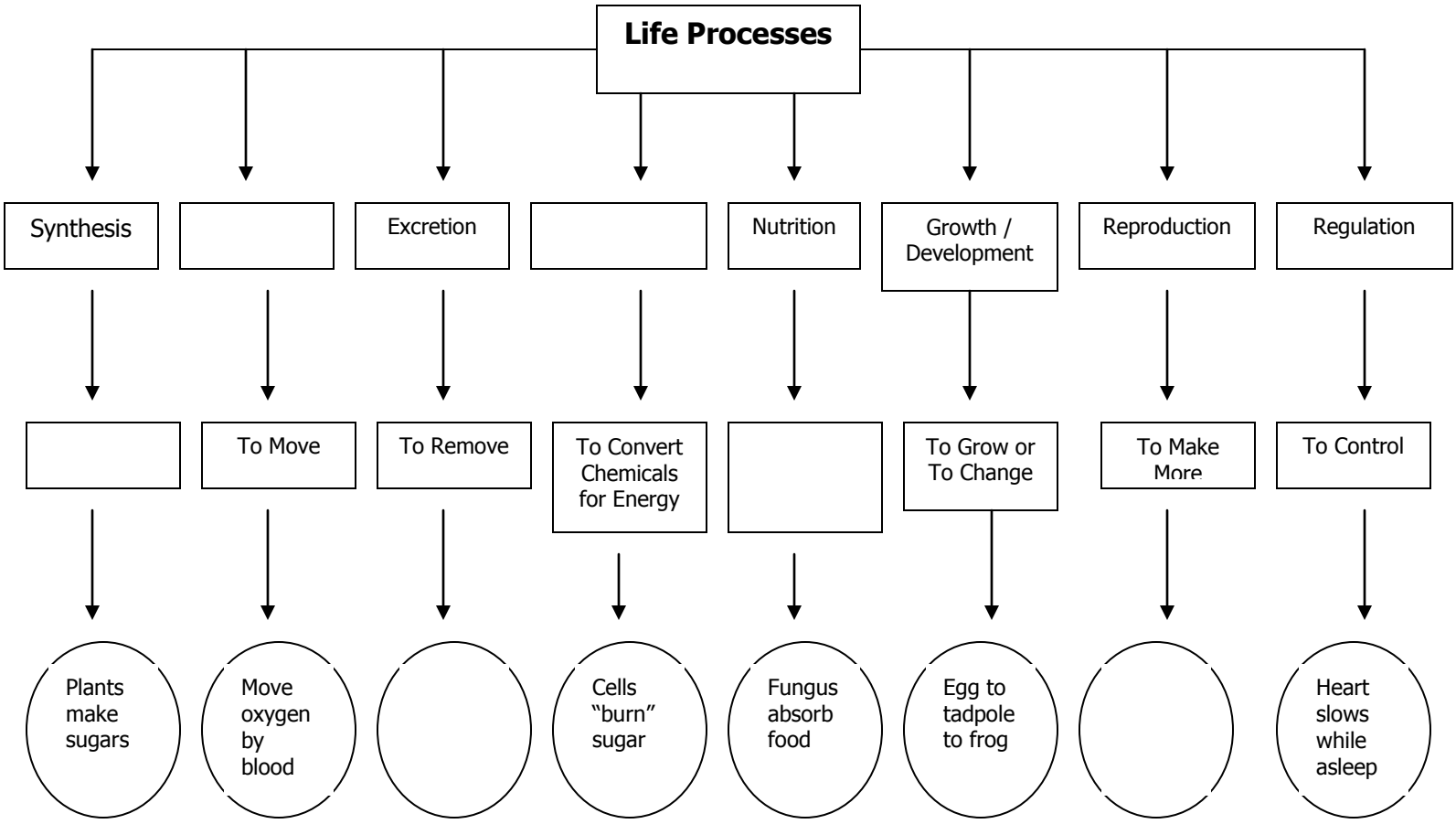
R-

R-

Check Yourself!

1. What is the basic unit of life?
2. A group of cells that perform a similar function are known as a _____.
3. What are two reasons an organism needs energy?
4. Label the following as an adaptation or a response to a stimulus.
   a. the hollow bones of a bird _____
   b. jerking your hand away from a hot stove _____

Concept Map: Life Processes



Directions:

1. Complete the concept map using the terms below to fill in the blank boxes:

- **Respiration** **° Transport**
- **To Build/Make** **° To Gain and Use Nutrients**
- **One cell divides into two** **° Exhale carbon dioxide**

2. What is the main idea of this concept map?

3. What are the 8 life processes?

4. What does "regulation" mean?

5. What is an example of development?

6. Make a concept map about the Scientific Method that is arranged <u>in the same pattern</u>.

Unit 1 / Module 1
Problem-Solving Set

Use the following experiment to answer questions 1-6.

Problem/Purpose
What is the effect of light color on plant growth?

Background Information
Plants use light for photosynthesis. The wavelength of the light is reflected in its visible color. Different wavelengths may produce different amounts of photosynthetic activity.

Hypothesis
If the light is red or blue, then the plant will grow less than it will in white light.

Procedure
Materials - 3 pea plant seeds, 3 pots, potting soil, 3 lamps, red bulb, blue bulb, white bulb, potting soil
Procedure -
1. Fill each pot with 100 grams of soil
2. Put a seed in the middle of each pot
3. Place each pot under a different colored bulb
4. Water each plant with 10ml of water each day for 20 days
5. Every seventh day, record the height of the plant

Observations/Data

	Plant 1 (white bulb)	Plant 2 (blue bulb)	Plant 3 (red bulb)
Week 1	0.5 cm	0 cm	0.5 cm
Week 2	1 cm	0 cm	0.5 cm
Week 3	6 cm	1 cm	2 cm

Analysis / Conclusions
The data shows that, overall, the plant in white light grew taller than the plants in red and blue light. The plant in red light grew 1 cm taller than the plant in blue light and showed earlier growth. Therefore, light color does affect plant growth.

1. What is the control group? _____
2. What are the experimental groups?_____
3. What is the independent variable?_____
4. What is the dependent variable?_____
5. Another scientist looked at the data and made the following statement: "Red light could be used to increase production of corn." Is this statement supported by the data?_____
6. Does the conclusion accept OR reject the hypothesis? _____

Use the experimental data to answer questions 7-10:
Quan is testing how soil acidity affects the life span of roly-poly bugs. Below is his data:

Group	pH	Days lived
A	3	5
B	5	30
C	7	60

Identify each of the following:

7. Control group –
8. Experimental groups –
9. Independent variable –
10. Dependent variable –

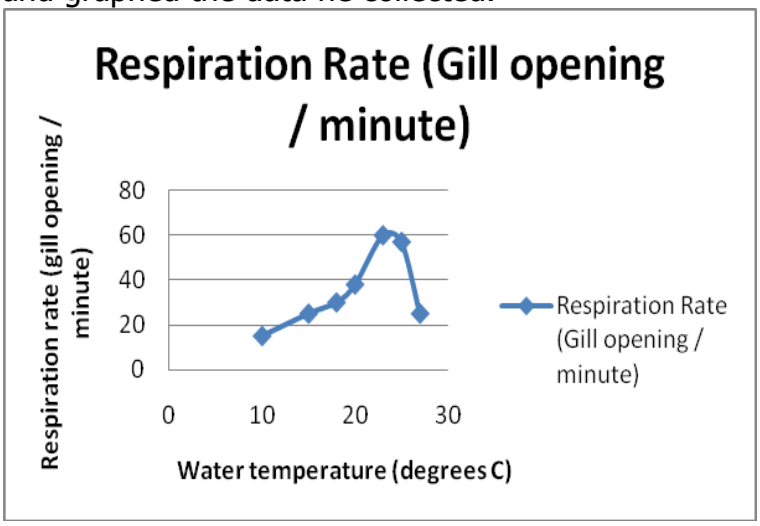
Use the experimental data to answer questions 11-14:
Amanda is testing how different amounts of caffeine affects the heart rate of rats. Below is the data she collected.

Group	Amount of caffeine	Heart rate (bpm)
A	0 mg	190
B	50 mg	225
C	100 mg	260

Identify each of the following:

11. Control group –
12. Experimental groups –
13. Independent variable –
14. Dependent variable –

A researcher investigated how water temperature affected the respiration rate of fish and graphed the data he collected.



15. What water temperature caused the lowest rate of respiration? _____
What water temperature caused the highest rate of respiration? _____

16. What might the scientist conclude after collecting this data?
_____
_____

A researcher tested the effect of temperature on the rate of seed germination and organized the data in a table:

Day of Observation	Total # of seeds germinated	
	10°C	20°C
7	0	5
10	20	35
15	40	70
20	45	80
25	45	80

17. What was the difference in the number of seeds germinated between days 10 and 15 at 10°C? _____
18. What was the difference in the number of seeds germinated between days 10 and 15 at 20°C? _____

19. Based on the data, which temperature causes seeds to germinate more rapidly? _____

In the table below, indicate the characteristic of life that is being described:

Example		Characteristic of Life
20.	A plant in the window grows toward the sunlight	
21.	You examine a leaf under the microscope and note tiny "compartments" made of smaller parts	
22.	You are tired when you get home from school so you eat an apple which your body digests	
23.	A hummingbird is born with a long, thin beak to help him reach the nectar of flowers	
24.	A butterfly emerges from a cocoon that was built by a caterpillar	
25.	A mushroom produces tiny spores that will grow into new mushrooms	

Match the description with the correct STERNGRR life process:

_____ 26. Plants absorb water from the soil and move it to the leaves

_____ 27. Sweat removes excess salt from the human body

_____ 28. A plant produces chemical toxins as a defense against predators

_____ 29. Bacteria decompose dead organisms as a source of food

_____ 30. Reptiles control their body temperature by moving in and out of the sun

_____ 31. A tadpole changes into a frog through the process of metamorphosis

_____ 32. Clownfish lay hundreds of eggs, but only a few survive to become adults

_____ 33. Humans gain oxygen by breathing, and use it in the production of energy

a. Synthesis
b. Transport
c. Excretion
d. Respiration
e. Nutrition
f. Growth and Development
g. Reproduction
h. Regulation

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

STOP!

True or False …What do you think?
1. Chemicals are made up of cells.
2. Organic means something is chemical-free.
3. We need water because each cell is filled with water.
4. Fats are bad for you.
5. It is important for your body to stay exactly the same.
6. Proteins are a good source of energy.
7. Carbohydrates help "build" your body structures.
8. An enzyme can be used again and again to speed up a chemical reaction.
9. A buffer keeps the pH at neutral.

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**: compounds that do not contain carbon, oxygen, and hydrogen. Water (made of the elements hydrogen and oxygen) is the most important inorganic compound for life:

Chemical formula of water:

Inorganic because…

i. Water 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 optimum environment Ex. transport of molecules in the cell

2. **Organic**: compounds that DO contain carbon, oxygen, and hydrogen. There are four main types:
   a. **Carbohydrates** (made of carbon, hydrogen, oxygen)
      Ex. Provide energy source for respiration (glucose)
   b. **Lipids** (made of carbon, hydrogen, oxygen)
      Ex. Insulate and protect organs in the body (fats)
   c. **Nucleic Acids** (made of carbon, hydrogen, oxygen, nitrogen and phosphorus)
      Ex. Allow traits to be passed from parent to child (DNA)
   d. **Proteins** (made of carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus)
      Ex. Provide specifically shaped molecules that can carry other molecules (hemoglobin carries oxygen)

The "Core Four" organic compounds:

1.

2.

3.

4.

C. Scientists can test for the presence 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 maintain homeostasis.
   a. The elements make up essential organic and inorganic compounds. Each type of molecule performs specific function/job in organisms (see examples above).
   b. Hydrogen is also donated or accepted by weak acid-base pairs to regulate the pH of a system like cells and blood. These weak acid-base pairs are called **buffers**.
      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

HOW does a buffer help maintain homeostasis?

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. Buffers help keep that pH level constant. 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. **Monosaccharides** are organic compounds made of carbon, hydrogen, and oxygen in a 1:2:1 ratio. Many monosaccharides bond together forming a larger compound chain called a carbohydrate.
   a. In plants the monosaccharide called **glucose** ($C_6H_{12}O_6$) bonds with other glucose molecules again and again to form **starch** or **cellulose**. The plant can

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

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

2. Functions of carbohydrates
   a. Energy is released when carbohydrates are digested. This is because glucose is used for cellular respiration.
      i. Monosaccharides (simple sugars) provide an immediate energy source.
      ii. Starch and glycogen are considered short term 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 structure and support 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 identifiers (like name tags).

3 functions of carbohydrates:

1.

2.

3.

B. Lipids

1. There are several types of lipids, but all contain subunits of glycerol and fatty acids made of carbon, hydrogen, and oxygen. These combine to make a very large molecule (macromolecule). It is different from a carbohydrate because of the ratio and because the smaller units do not link together to form a chemical chain.
   a. Fats 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 cell membrane.

c. **Steroids** are lipid rings and help regulate the organism through cell communication (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 long-term (weeks, months) energy sources.

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

b. Fats stored in the body act as insulation and protection for internal organs.

c. Some hormones 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 carbon, hydrogen, oxygen, nitrogen and phosphorus . Many nucleotides bond together to make up a long chain called a **nucleic acid**. There are two basic types of nucleic acids:

a. **DNA** is a double chain of nucleotides found in all cells.

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

2. Functions of nucleic acids
   a. DNA makes up genes. Genes determine traits, such as hair color. Genes are passed from parent to offspring.
   b. DNA controls cellular activities 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 production of proteins.

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 20 different amino acids, 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 shape of a protein determines its function. If a protein **denatures** (loses its shape) it cannot function.
   a. **Hemoglobin** is a protein shaped to hold oxygen for transport through the bloodstream.
   b. A group of proteins called **enzymes** are shaped to fit and react with specific molecules.

What happens when a protein "denatures"?

2. Functions of proteins
   a. Some proteins, called pigments, 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 antibodies.

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 keratin (a protein) found in hair and nails.
d. Some proteins are used for transport through the cell membrane or in the bloodstream (ex. hemoglobin)
e. Some proteins are used for communication 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 speed up chemical reactions, 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

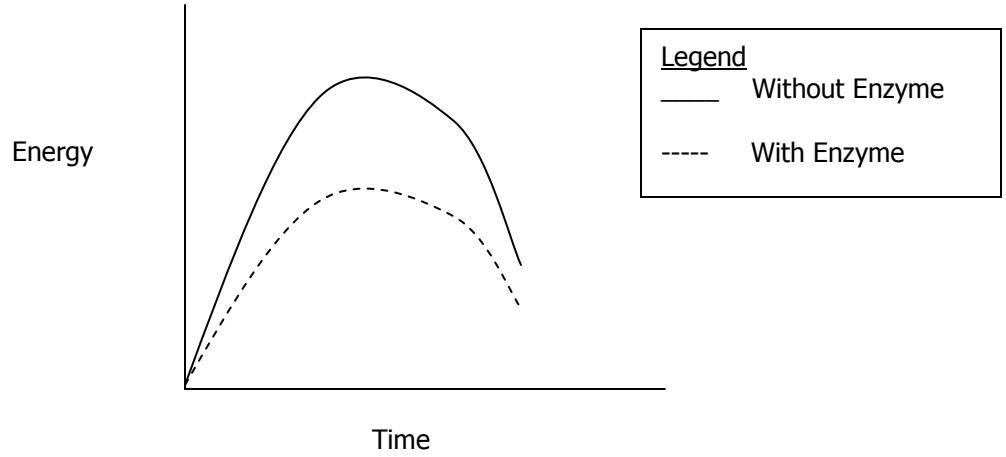
1. **Metabolism** (chemical reactions) requires certain conditions to occur. Enzymes regulate metabolism, allowing life to continue. Enzymes speed up reactions, making an enzyme a **biological catalyst**.

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

The main job of enzymes:

Reaction vs. Energy

Explanation of graph:



B. The structure of an enzyme determines its function

1. Enzymes are usually proteins. Proteins have a definite 3-D structure based on how the amino acid chains fold.
   a. On the enzyme, there is a place where the target molecule can attach. 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 substrate will not fit. 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 collides 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 lock and key.

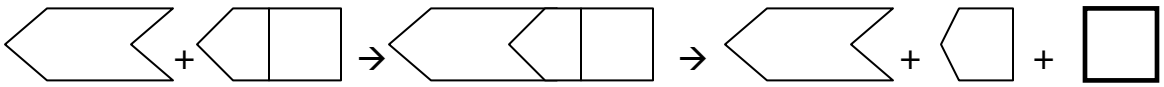
c. The enzyme changes the substrate in some way

   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

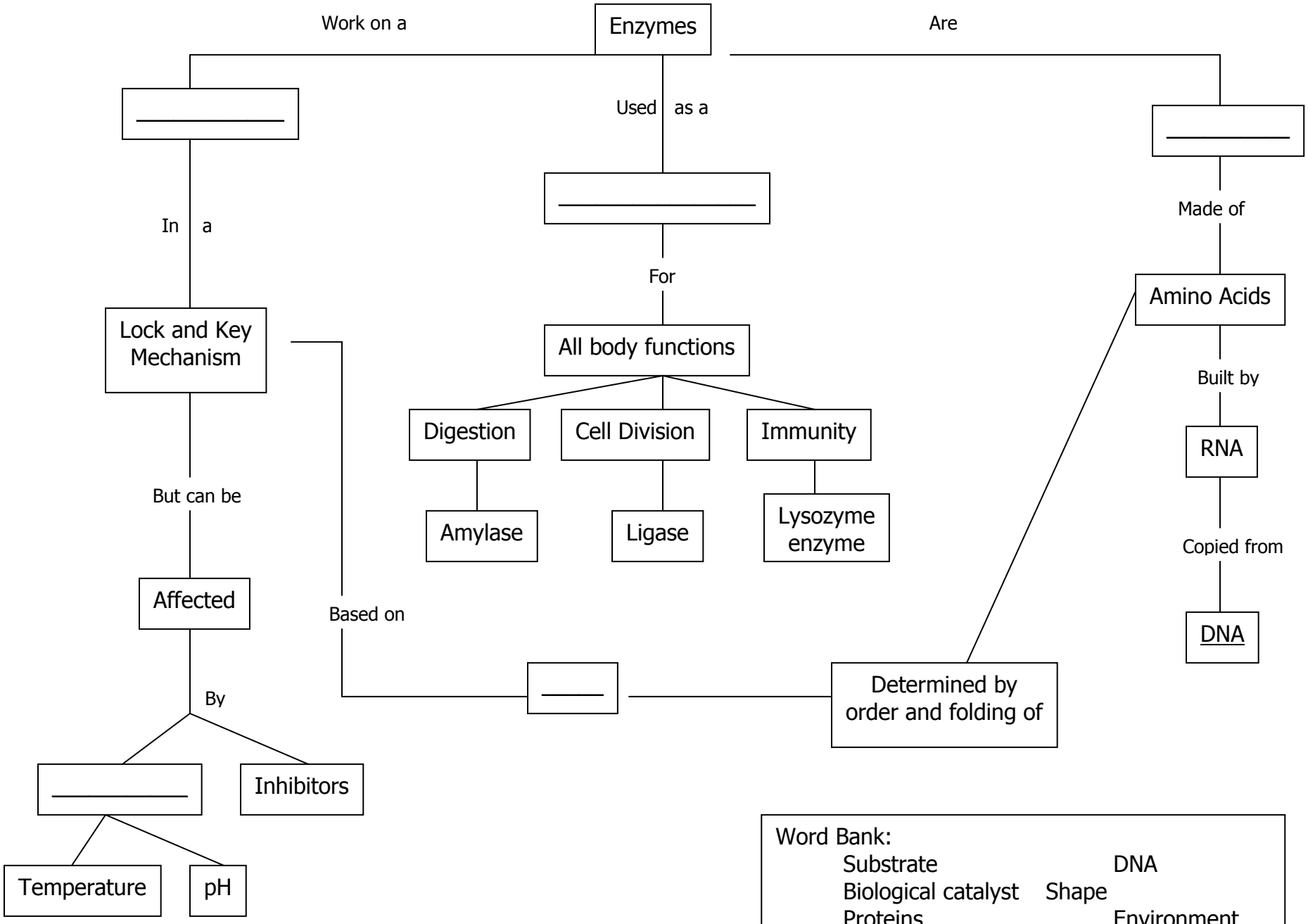
C. Enzymes have distinguishing characteristics

1. Enzymes are specific. 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 reusable. 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.

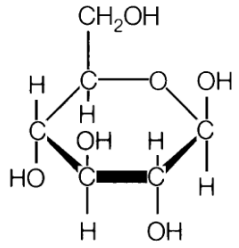


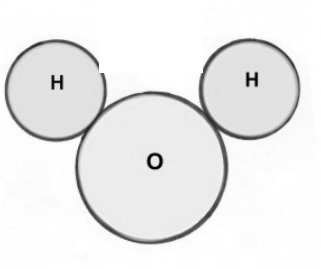
Word Bank:

Substrate		DNA
Biological catalyst	Shape	
Proteins		Environment

Unit 2 / Module 2
Problem-Solving Set

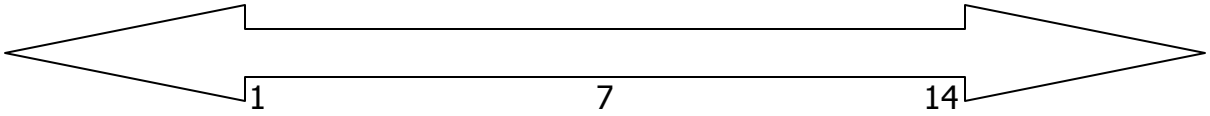
For each of the following chemical structures, determine if the structure is organic or inorganic. Write your answer on the line below the structure.

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

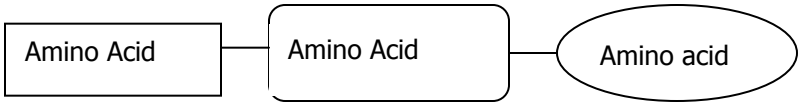


4. When a person has "heartburn" (also know as acid reflux), they may take medication such as Tums®, or Alka Seltzer®. Explain how this makes the person feel better, using the words "neutralize" and "buffer".

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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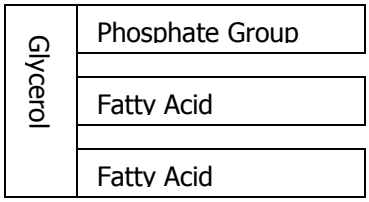

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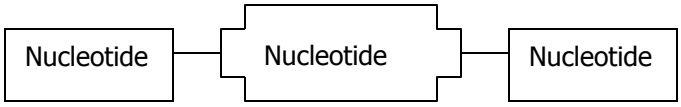

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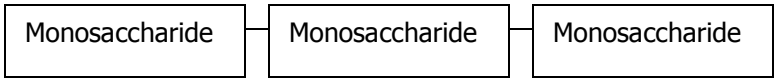


_____

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?

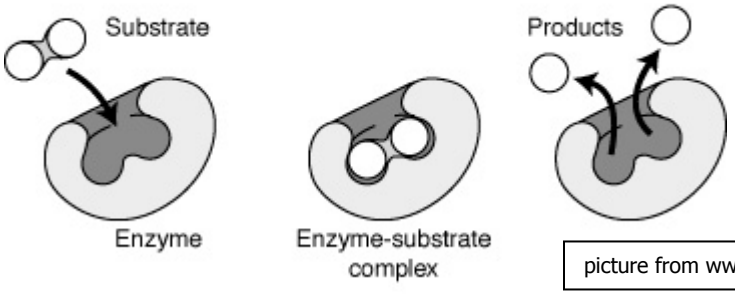
   _____

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

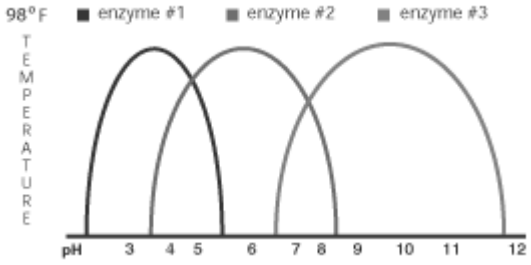
11. Color the diagram using the key below:
    - Enzyme = Blue
    - Substrate = Green
    - Product = Orange
    - Active site = Red

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"

    __ __ __ __ __ __ __ __ __ __

Unit 2: Cellular Chemistry, Structure, and Physiology

Module 3: Cellular Structure

NC Essential Standard:

- 1.1 Understand the relationship between the structure and function of cells and their organelles

STOP!

True or False …What do you think?

1. All cells are the same size and shape – there is a "generic" cell.
2. It is possible for an organism to only consist of ONE cell.
3. Some parts of living organisms are NOT made of cells.
4. Cells need molecules of food to carry out life functions.
5. Cells are filled with water.
6. Molecules such as carbohydrates and proteins are made of cells.
7. There are only two kinds of cells – plant and animal.
8. Cells have to excrete waste.
9. Life processes (STERNGRR) occur at the cellular level.
10. All cells in the body of a human are essentially the same.

I. How were cells discovered?

A. New technologies lead to new discoveries

1. Robert Hooke – Invented the first microscope and was the first to observe and name the small units that make up organisms. He called those small units **cells** because of the appearance of the structures in the dead cork he observed.
2. Anton van Leeuwenhoek – Improved the microscope and procedures for observing cells. He was able to clearly see living cells when observing the scrapings from his teeth.

Cells observed by…
Hooke:

Leeuwenhoek:

B. Through the cooperative efforts of many individual scientists, a unifying **cell theory** developed:

1. All organisms are made of cells.
2. Cells are the structural and functional units of organisms.
3. All cells come from pre-existing cells.

II. Are all cells alike?

A. Two main types of cells

1. **Prokaryotic** Cells

Watch It!

a. Simplest type of cell.

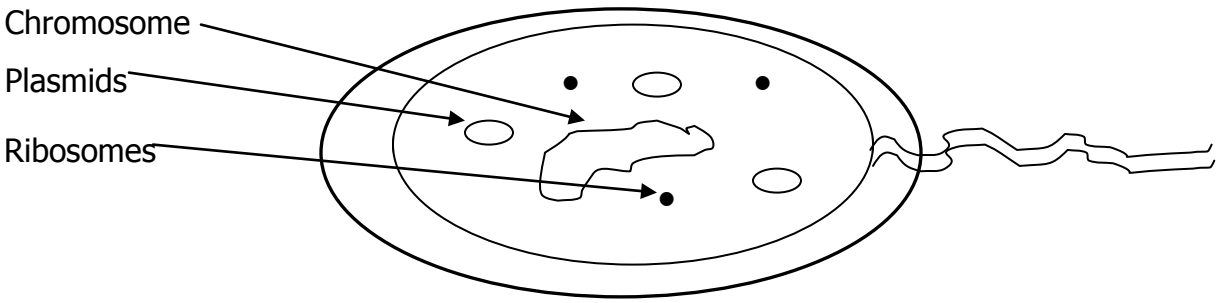
b. Includes only bacteria.

c. Structure of a prokaryotic cell

i. No nucleus

ii. No membrane bound organelles

iii. Includes: circular chromosome (DNA), **plasmids** (smaller rings of DNA), and ribosomes.



Prokaryotic	Eukaryotic

2. **Eukaryotic** Cells

a. More complex than prokaryotic cells

b. Includes protist cells, fungi cells, plant cells and animal cells (i.e. – everything EXCEPT bacteria cells)

c. Structure of a eukaryotic cell

i. Chromosomes contained within a nucleus

ii. In addition to ribosomes contains membrane bound organelles

B. Cell Specialization

1. Different cells have different specialized structures and different specialized functions. The specialized function of the cell depends on the unique environment of the cell.

Ex. Fresh water vs. salt water environments

Drawing of nerve cell:

2. The specific form (structure) of a cell allows it to perform a specific function – **FORM RELATES TO FUNCTION.**

   Ex. Nerve cells are long and thin to transmit messages

Check Yourself!

1. Who first observed dead cells? Who first observed living cells?

2. What are the two main types of cells?

3. How is the location of the DNA different in prokaryotic and eukaryotic cells?

4. What is cell specialization?

5. In cells, form relates to _____.

III. What do cells share?

A. Structures found in ALL cells

4 structures found in ALL cells:

1.

2.

3.

4.

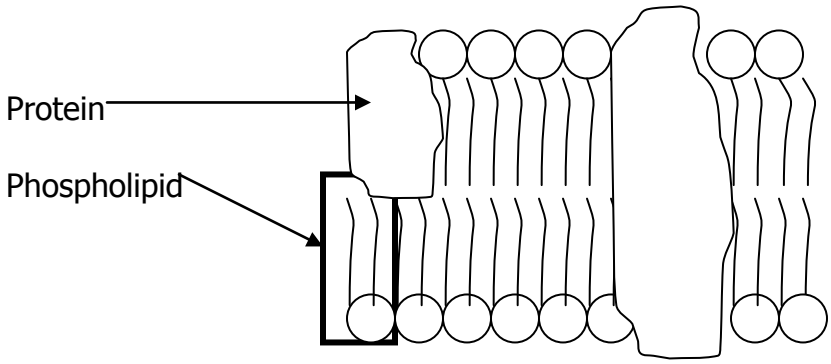
1. **DNA** organized as **chromosome**(s). DNA directs cell activity.
2. **Cytoplasm** is the "filling" of the cell and is made of up to 90% water. Water provides the necessary environment for all the chemical reactions the cell needs.
3. **Ribosomes** are organelles that are the site of protein synthesis. Proteins are essential for enzymes, structure and communication.
4. **Cell membrane** (plasma membrane)

a. Composed of a **phospholipid bilayer** with embedded proteins. The fluid mosaic model describes the structure of the cell membrane.
    i. Fluid – Individual phsopholipds and proteins can move past each other; they are not fixed in one position.
    ii. Mosaic – The membrane has more than one type of molecule (phospholipids and proteins)

b. Functions of the cell membrane
    i. **Selectively permeable** – regulates what enters and leaves the cell. This helps maintain homeostasis.
    ii. Gives the cell (cytoplasm) shape.

The cell membrane is also called….

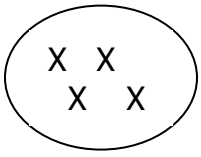
and is….
S_____
P_____



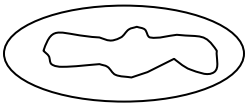
B. Structures (**organelles**) found in EUKARYOTIC cells

1. **Nucleus**- surrounds the chromosomes for additional protection; is made of a phospholipid bilayer

Organelle means….



2. **Mitochondria** – site of cellular respiration which produces cell energy (ATP). Structure contains folded membranes which increases surface area allowing more space for more reactions.



Summary of structure/function:

Nucleus –

Mitochondria –

Vacuole –

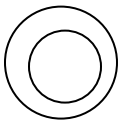
Lysosome –

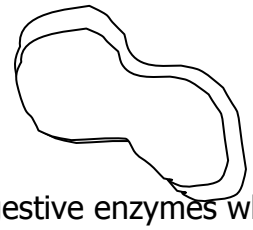
ER –

Golgi –

Chloroplast -

3. **Vacuoles** – store food, waste or water to be used inside the cell or excreted from the cell. Size differs in plant vs. animal cells.

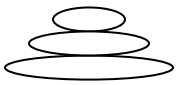




4. **Lysosomes** – contain digestive enzymes which digest food contained in vacuoles as well as old or damaged cell parts

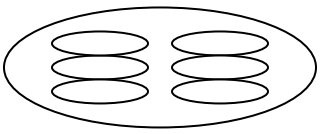
5. **Endoplasmic Reticulum** (ER) – a series of interconnected folded membranes that function in modifying (changing) proteins, detoxification of alcohols, and communication.

6. **Golgi Complex** – packages materials for export from cells.



C. Structures found ONLY in plant and plant-like cells

1. **Chloroplasts** – organelles full of chlorophyll that are the site of photosynthesis which produces sugars ($C_6H_{12}O_6$); composed of folded membranes for more surface area.



Plant only	Animal only

2. **Cell wall** – provides extra support, protection, and shape for the cell; found outside the cell membrane and made of cellulose.

D. Structure found ONLY in animal cells

Centrioles – organelle that helps with cell division in animal cells.

Check Yourself!

1. What four structures are found in all cells?

2. What is the function of the mitochondria?

3. What is the function of a ribosome?

4. What term refers to small cell structures?

5. What two structures are found in plant and plant-like cells?

IV. How do cells communicate with other cells?

A. Cells must communicate with other cells in order to maintain homeostasis. The signal usually causes a change in the target cell.
   Ex. Neurons (nerve cells) must stimulate muscle cells.
   Ex. Brain cells must signal liver cells to release stored sugar

B. Type of communication depends on the distance between cell sending message and receptor (target) cell.
   1. Short Distance Communication
      a. Some cells are physically connected to each other at **junctions**. This allows one cell to send a chemical or electrical message directly to the next cell.

Drawing of….

Cell Junction

Synapse

Ex. One heart cell uses an electrical impulse to stimulate neighboring heart cell to contract

b. Some cells are separated by a very short distance called a **synapse**. These cells (typically nerve cells) release a chemical message into the synapse and the other cell receives the message using special receptors.
Ex. Pain receptor nerve cell sends message to spinal cord nerve causing reflex reaction.

2. Long Distance Communication
   a. Some cells are so far away they must use a transport system such as the blood. Often hormones are used in this type of communication.
   Ex. A hormone released from the brain stimulates uterine muscle cell contractions during child birth.
   b. When long-distance communication is used, the signal must be specifically shaped so that only the target cell will receive the signal. This involves the shape of the hormone and the shape of cell membrane proteins.

Long distance cell communication uses _____ to affect _____ cells.

Check Yourself!
1. Name two ways cells that are close to each other communicate.

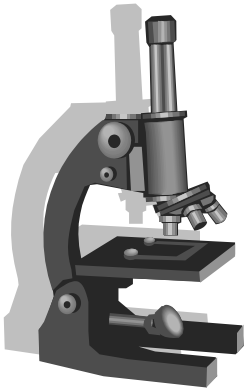
2. What is the function of a hormone?

V. How can we observe cells?

A. Compound Light Microscope

1. Has two lenses – **ocular** (eyepiece) and **objective**
2. In order to be viewed, specimen must be thin (so the light may shine through the specimen) and placed on a slide.

Label the ocular lens and the objective lens:



3. Specimen may be stained to better see structures

B. Electron Microscope

1. Uses electrons to produce an image
2. Types:
   a. Scanning Electron Microscope (**SEM**)
      i. Electrons scan the surface of a specimen
      ii. Produces a 3-D image
   b. Transmission Electron Microscope (**TEM**)
      i. Designed to look at structures inside a cell
      ii. Capable of greatest magnification

C. Limitations of microscopes

1. **Magnification** is limited by the strength of the lens.
   a. Calculating magnification:
      Ocular lens x objective lens = total magnification
   b. Example:
      Ocular (10x) x objective (40x) = 400x
2. As magnification increases **resolution** (sharpness) decreases.

Check Yourself!

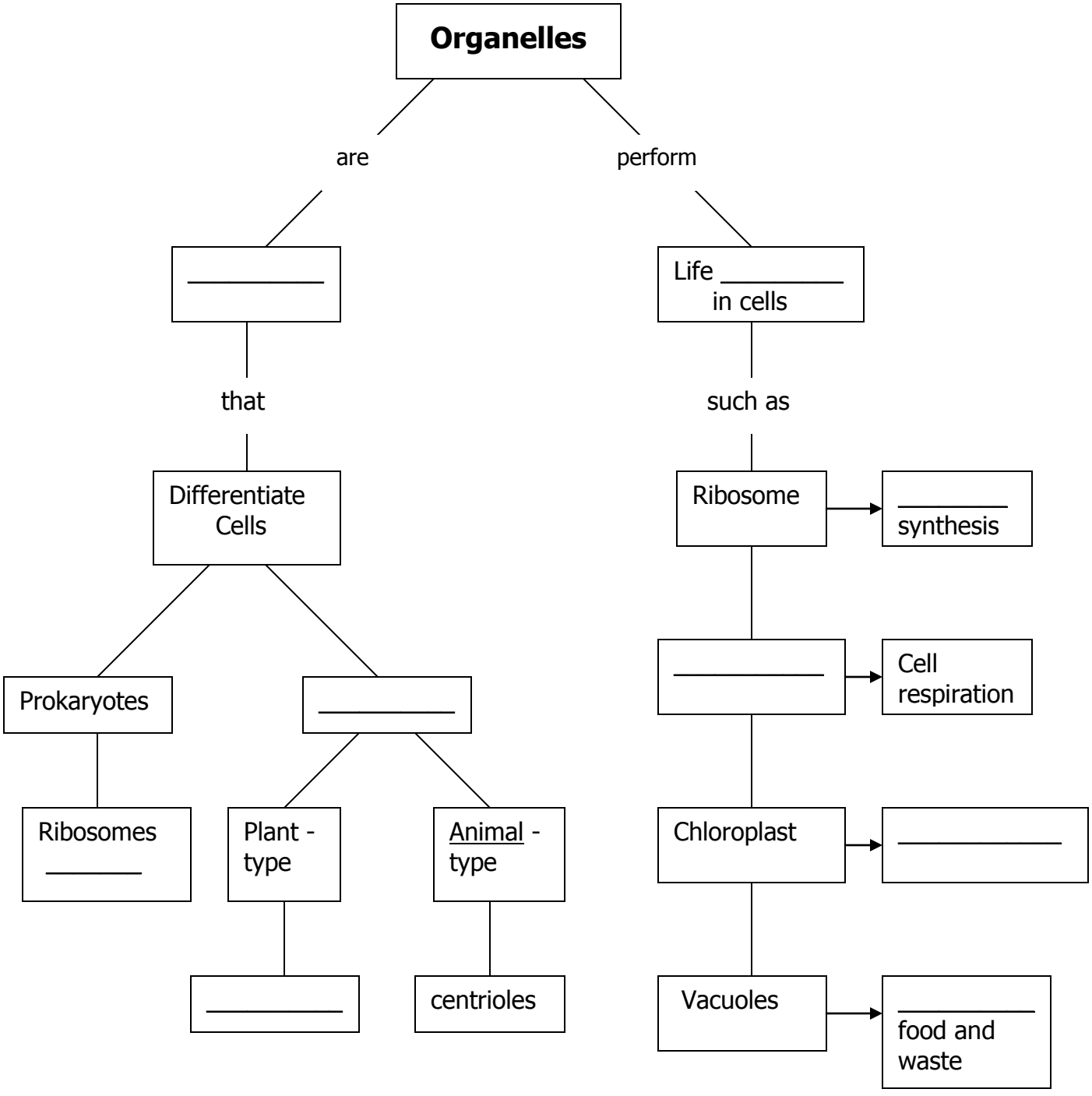
1. Why must specimens be thin for a compound light microscope?

2. Which microscope provides the highest possible magnification?

3. If the ocular lens is 10x and the objective lens is 10x then the total magnification is?

4. As magnification increases resolution _____.

Concept Map: Cell Structure



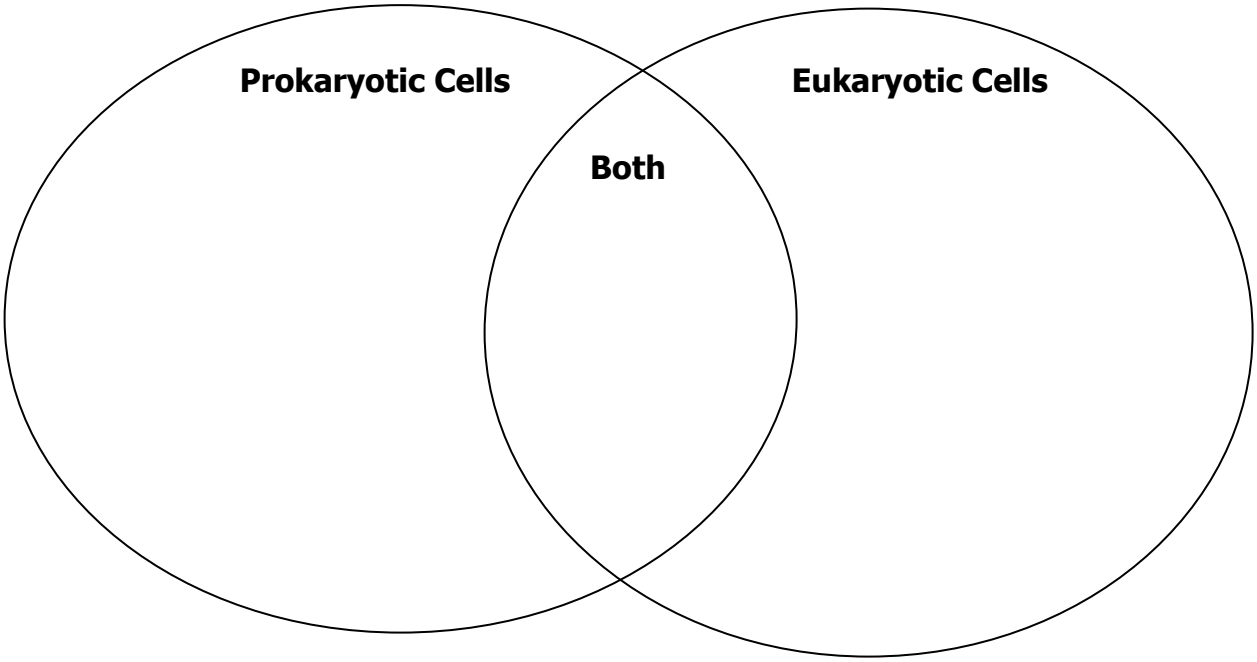
Word Bank:

Animal	Only
Chloroplast	Photosynthesis
Eukaryotes	Protein
Functions	Store
Mitochondria	Structures

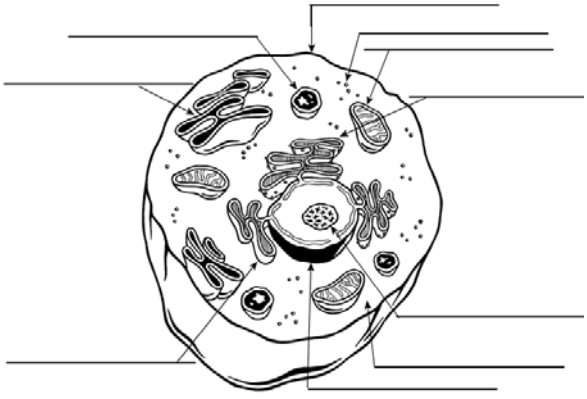
Unit 2 / Module 3
Problem-Solving Set

1. Place the following terms in the correct area of the Venn diagram for cell types using the word bank below:

Nucleus	Cell Membrane	Cell Wall
Ribosome	Mitochondria	Cytoplasm (cytosol)
Golgi body	Vacuoles	Endoplasmic Reticulum
DNA	Plasmid	Lysosome



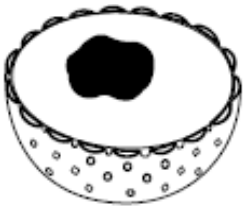
2. Label the cell below.



Explain why this cell is considered EUKARYOTIC.

_____
_____
_____
_____
_____

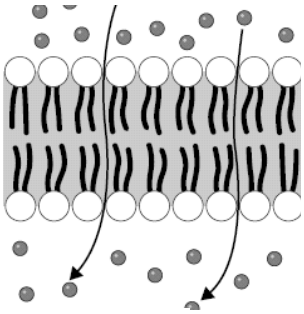
3. Match the pictures of different cell structures to the correct name.



a

b

c



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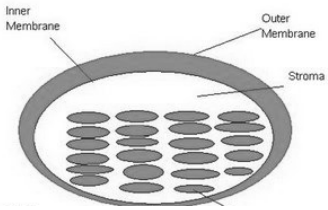


e

1. Mitochondria _____
2. Chloroplast _____
3. Endoplasmic Reticulum _____
4. Plasma Membrane _____
5. Nucleus _____

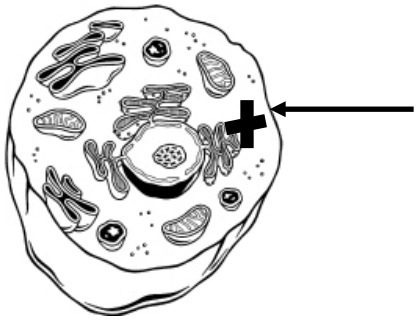
4. Identify the cell structure that matches the function

_____ converts solar energy to chemical energy	a. nucleus
_____ converts stored chemical energy to ATP	b. vacuole
_____ digests larger food particles and wastes	c. ribosome
_____ stores food, water, or waste	d. mitochondria
_____ location of protein production	e. chloroplast
_____ regulates what enters and leaves the cell	f. lysosome
_____ contains chromosomes	g. cell membrane

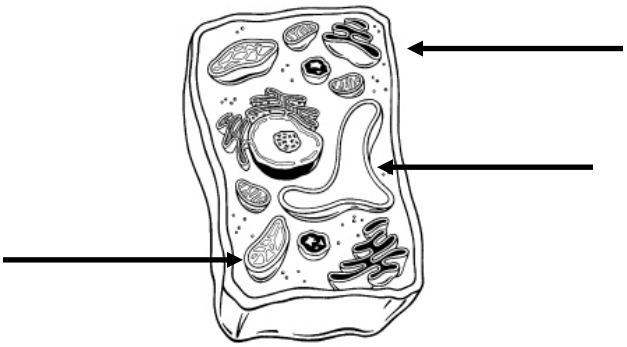
Image Credits:
http://www.ivytech.net/twmurphy/text_pg/pro_cell.jpg
Prentice Hall Review Book – Version B
http://www.cs.utexas.edu/users/almstrum/cs373/s2s/cs373-class/s2s/latest/recursion1/images/doc/cell_euk.gif

5. Label the plant and animal cells below with the distinguishing structures indicated by arrows.

Animal Cell



Plant Cell



6. Identify the cell structure that would be most useful for the proper functioning of the cells below.

_____a. White blood cells must capture and digest invading pathogens.

_____b. Liver cell of a human must be able to detoxify substances ingested and therefore requires a large network of tubules for surface area to break down toxins.

_____c. Cactus plant cells are adapted for storage of large amounts of water in case of drought.

_____d. Plant cells in the leaves face the sun and produce large amounts of carbohydrates for use in winter.

_____e. Red blood cells must make massive amounts of hemoglobin (a protein) that is necessary for your cells to carry oxygen.

_____f. Muscle cells of your upper arm need lots of energy to contract during the day.

_____g. Cells of the digestive tract that secretes digestive enzymes, produce and package vacuoles of digestive enzymes for secretion into the small intestines.

7. Identify the type of communication the cells below might use.

Junctions Synapses Transport System

a. When someone pinches the skin on your arms, your skin stays connected. _____

b. When you grow (increase in height) the message must be received by many different tissue types all over the body (ex. bone, skin, muscle). The signal for this growth is sent out via a growth hormone.
_____

c. In order for your muscles to contract, the muscle cell must be stimulated by a nerve. The nerve and muscle cell do not touch, a chemical messenger carries the signal a very short distance.
_____

Unit 2: Cellular Chemistry, Structure, and Physiology

Module 4: Cellular Physiology

NC Essential Standard:
- 1.2 Analyze the cell as a living system
- 4.2 Analyze the relationships between biochemical processes and energy use in the cell

STOP!

True or False …What do you think?

1. "Osmosis" means to absorb something.
2. Cells are able to excrete waste.
3. Cells obtain energy by gaining nutrition from food.
4. Plants use sunlight for food.
5. Plants use heat from the sun as a source of energy for photosynthesis.
6. The main goal of photosynthesis is to produce oxygen.
7. Some living things can exist without oxygen.
8. Food is synonymous with energy.
9. Respiration is synonymous with breathing.
10. Only plants photosynthesize and only animals respire.

I. Are my cells alive?

A. Cells are the basic unit of structure and function in living organisms.

1. All living things are made of cells
   a. Unicellular organisms are made of one cell. Ex. Bacteria
   b. Multicellular organisms are made of many, many, many cells. Ex. YOU!
2. All life processes occur at a cellular level.
   a. In a multicellular organism, many of the bodily functions (breathing and eating) are necessary to supply individual cells with things the cells need.
   b. The interactions of all the individual cells in a multicellular organism create a need for other bodily functions (excreting wastes).

B. Cells must interact with their environment to maintain homeostasis.
   1. In order for a cell to gain nutrients, the nutrients must be delivered to the cell (ex. by blood) or taken directly from the environment.
   2. In order for some cells to generate energy, they require oxygen. Therefore, this oxygen must be delivered to the cell (ex. by blood) or taken directly from the environment.
   3. Cells affect their environment by releasing wastes into their surroundings. Ex. Algae release oxygen into the lake.

II. How do things get into and out of the cell?

A. All things entering or leaving the cell must pass through the cell membrane.
   1. The cell membrane is **selectively permeable**.
   2. Membranes contain structures that allow movement
      a. The membrane contains **pores** (holes) that allow very small molecules to move in and out freely.
      b. The membrane also contains **transport proteins** that are specifically shaped to allow essential molecules, such as water, into and out of the cell

Two ways that molecules move through the cell membrane:
1.

2.

B. Some types of cell transport DO NOT require energy. This is called **passive transport**.
   1. Molecules are constantly in motion. The movement of molecules is random.
   2. **Diffusion** is the term used to describe the movement of molecules from areas of high concentration to areas of lower concentration due to random movement. Diffusion can occur in the air, in water or across a cell membrane.
      Ex. A drop of red dye spreads throughout the water
      Ex. The smell of burnt popcorn spreads through the house

Passive transport is movement of molecules from _____ to _____ concentration.

Differentiate between the terms "diffusion" and "osmosis":

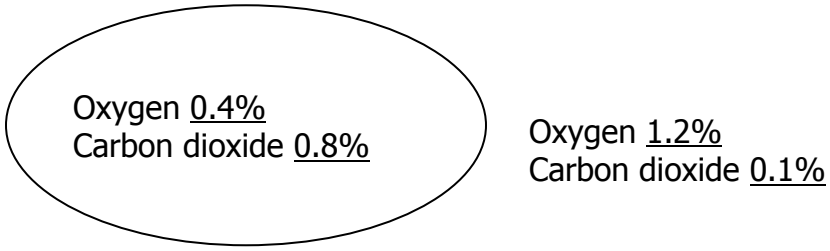
Diffusion –

Osmosis –

a. **Concentration gradient** is the term used to describe the difference between higher and lower concentration.
b. **Osmosis** is the term used to specifically describe the movement of water across a membrane due to diffusion.

3. The principles of diffusion (and osmosis) can be used to predict the response of cells in different environments.
   a. An example of diffusion:
      A cell has a concentration of 0.8% carbon dioxide gas and 0.4% oxygen gas. The blood surrounding the cell has an oxygen concentration of 1.2% and a carbon dioxide concentration of 0.1%. What will the cell lose? What will a cell gain?

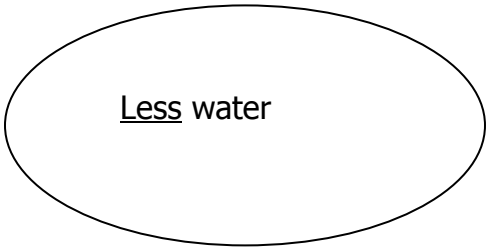
Explain WHY the oxygen and carbon dioxide move as they do…



Answer:
Oxygen will diffuse into the cell and carbon dioxide will diffuse out of the cell. This is called gas exchange.

   b. Examples of osmosis:
      i. A blood cell has the same concentration of water and salt as saline solution. A doctor who failed high school biology and did not listen to the attending nurse used a injection full of distilled water (100% water). What will happen to the blood cells surrounded by the distilled water? (Hint: You will feel excruciating pain.) Explain.

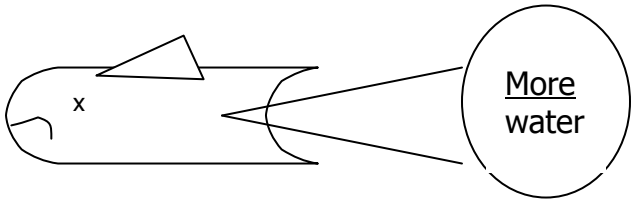
DRAW ARROWS on each of the cells shown in the notes to illustrate water moving across the cell membrane.



Answer:

Water will move into the cell through the process of osmosis, causing the cell to swell and possibly burst.

ii. You go the pet store and purchase a fresh water fish. When you get home and place the fish in a salt water aquarium. The fish dies and you cry out "Why?" (No seriously, why?)



Fish Cell

Answer:

Water in the fish's cells left the cell due to osmosis. The loss of water in the gill cells caused the death.

4. The point at which the molecules are evenly dispersed is called **equilibrium**.

Equilibrium means….

a. Several factors affect the speed at which equilibrium is reached. These factors include temperature (higher temperature speeds the rate of diffusion) and concentration gradient (steeper gradients speed diffusion).

b. At equilibrium molecules continue to move but there is no net change in the concentration (distribution) of molecules.

C. Some types of transport DO require energy. This is called **active transport.**

Active transport is movement of molecules from _____ to _____ concentration

1. Active transport moves molecules against the concentration gradient (from low concentration to high concentration)
2. Active transport also moves large molecules into and out of the cell that could not normally cross the cell membrane.
3. The cell uses a special kind of energy for this transport. The chemical the cell uses is called ATP.

Check Yourself!

1. Why must some multicellular organisms breathe and eat?

2. Why do cells interact with their environment?

3. What structure do molecules pass through when entering or leaving the cell?

4. What type of transport requires no energy and includes diffusion and osmosis?

5. What is a concentration gradient?

6. What term is used to describe the diffusion of water across a membrane?

7. What type of transport moves molecules against the concentration gradient?

8. What term is used to describe an equal distribution of molecules between a cell and its environment?

III. How does energy from the sun become energy for life?

A. Organisms called producers convert light energy to chemical energy using a process called **photosynthesis**. The chemical energy produced in photosynthesis is in the form of sugar. This allows producers to store the energy for later use.

The goal of photosynthesis is …

B. Photosynthesis takes place within the cell.
   1. In eukaryotic cells, organelles called chloroplasts are the site of photosynthesis.
   2. Chloroplasts are filled with a pigment called **chlorophyll**. This pigment allows the cell to "gather" energy from light waves.
   3. Some prokaryotic cells can photosynthesize, but they do NOT have chloroplasts. They do, however, contain chlorophyll.

Watch It!

C. Photosynthesis is a metabolic pathway. This means it is a series of chemical reactions. All of these reactions can be simplified into one chemical equation:

$$\mathbf{CO_2 + H_2O + sunlight\ (radiant\ energy) \rightarrow C_6H_{12}O_6 + O_2}$$

(Reactants) (Products)

Reactants for photosynthesis:
1.
2.
3.

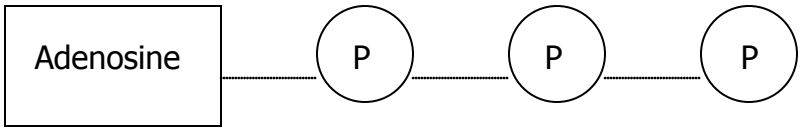
Products of photosynthesis:
1.
2.

   1. The **reactants** (things that are used) for photosynthesis are obtained from the environment. The carbon dioxide enters the leaves from the air and the water enters the roots from the soil.
   2. The **products** (things that are made) of photosynthesis include sugar and oxygen. Sugar is stored in the cell and used as food. Oxygen is released into the air.

D. Photosynthesis provides no DIRECT source of energy for the cell. The cell must convert the sugar produced to another form of energy: ATP.

IV. What is this ATP, and why should I care?

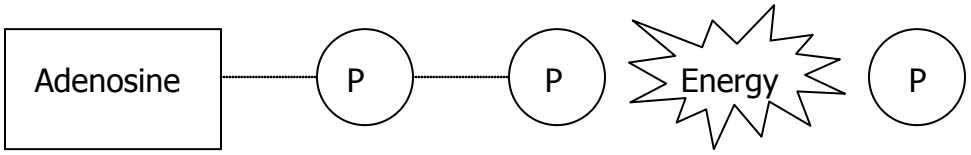
A. **ATP** stands for adenosine triphosphate. This basically means that it is a chemical with three phosphate groups attached.



ATP is used for….

B. The cell uses ATP for energy. ATP is much smaller and faster to use than a larger molecule such as sugar. The energy in ATP is in the bonds connecting the four parts together.

C. When the cell needs energy from ATP, it uses enzymes to break the third phosphate off of the molecule. The energy released is used for things in the cell such as active transport. Removing the third phosphate creates ADP and a loose phosphate.



D. ATP can be recycled. When more energy is available, a third phosphate is added to ADP to make more ATP.

The goal of cellular respiration is …

V. How do cells use the sugar to make ATP?

A. All cells must use a process called **cellular respiration** to create ATP. Cellular respiration converts sugar (produced in photosynthesis) to create ATP.

B. Cellular respiration takes place within the cell.

Types of organisms that use cellular respiration:

1. In eukaryotic cells, organelles called mitochondria are the sites of cellular respiration.
2. Mitochondria use many enzymes to break down sugar (glucose) and store the energy in the chemical bonds of ATP.
3. Prokaryotes also use cellular respiration, but they do NOT have mitochondria. Instead, prokaryotes use parts of their cell membrane.

C. Cellular respiration is also a metabolic pathway. The simplified equation for cellular respiration is:

$$\mathbf{C_6H_{12}O_6 + O_2 \rightarrow H_2O + CO_2 + ATP}$$

(Reactants) (Products)

Reactants of cellular respiration:
1.
2.

Products of cellular respiration:
1.
2.
3.

1. The reactants of respiration are glucose and oxygen. The sugar (glucose) is obtained from the vacuole (in plant cells) or from ingestion (eating) of food. If oxygen is used, it is obtained from the air.
2. The products of respiration are ATP, water and carbon dioxide. The water and carbon dioxide are released into the environment as waste products. ATP is kept in the cell for use as an energy molecule.

D. There are two types of cellular respiration: aerobic and anaerobic.

Differences in ATP production in aerobic vs. anaerobic respiration:
Aerobic –

Anaerobic -

1. **Aerobic respiration** requires the use of oxygen and makes A LOT of ATP.
2. **Anaerobic respiration** (also called **fermentation**) takes place when no oxygen is available to the cell and produces very little ATP. However, this process is much faster than aerobic respiration.

Anaerobic respiration is also called ….

a. In most microorganisms, fungi, and plant cells, anaerobic respiration produces alcohol as a waste product (**alcoholic fermentation**).
b. In animal cells, anaerobic respiration produces lactic acid as a waste product (**lactic acid fermentation**).

Check Yourself!

1. What pigment AND reactants are required for photosynthesis to occur?

2. What does photosynthesis produce?

3. Where does photosynthesis occur in eukaryotic cells?

4. Where is the energy in ATP stored?

5. Why does the cell use ATP instead of sugar for energy?

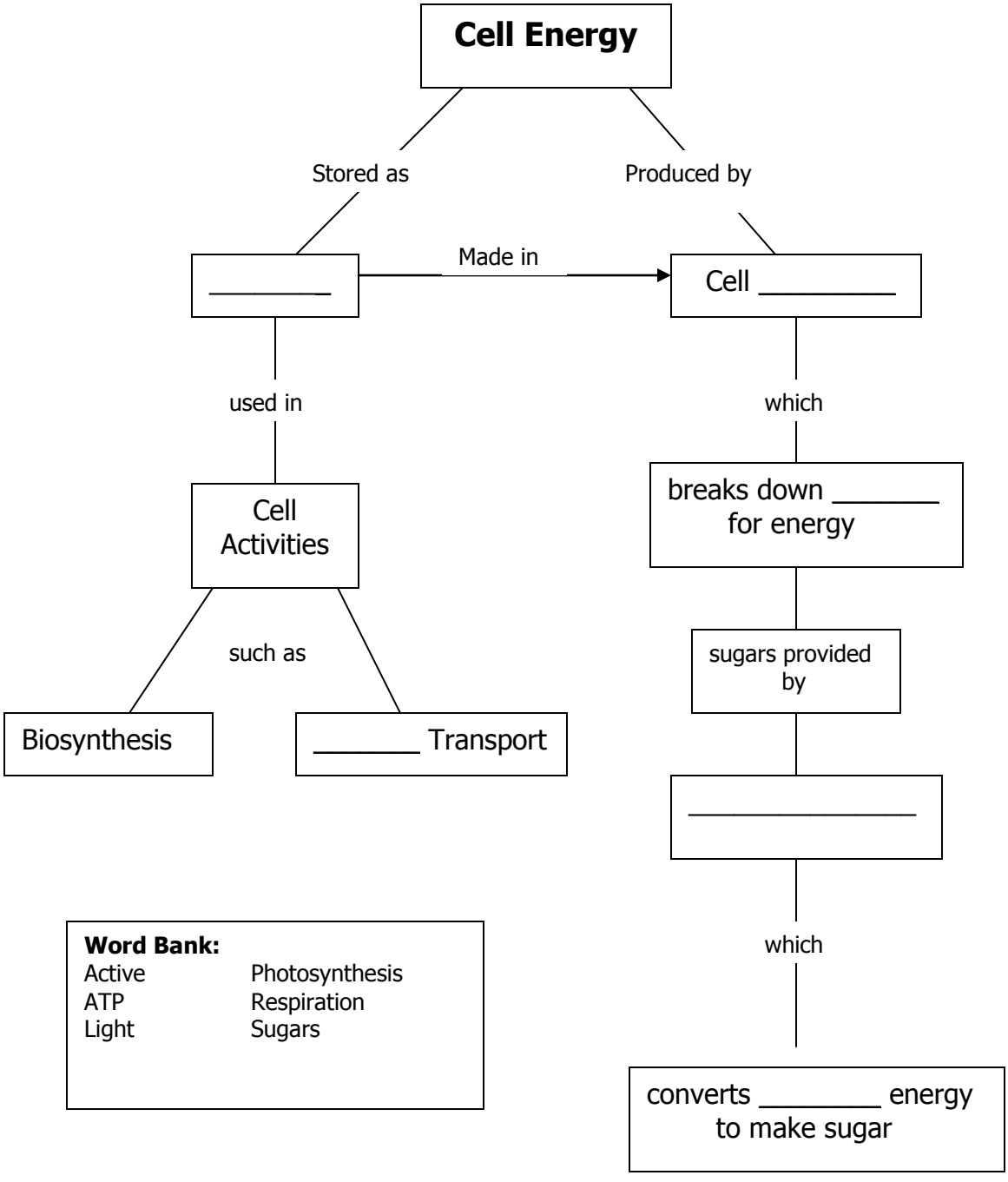
6. What reactants are required for cellular respiration to occur?

7. What does cellular respiration produce?

8. Where does cellular respiration occur in eukaryotic cells?

9. How is fermentation alike and different from aerobic respiration?

Concept Map: Cell Energy



Unit 2 / Module 4

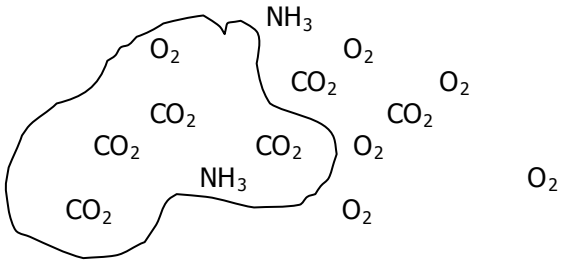
Problem-Solving Set

1. Oxygen and carbon dioxide molecules are able to diffuse through the cell membrane. Inside a cell, the concentration of oxygen molecules is 0.5% and the concentration of carbon dioxide molecules is 0.8%. In the blood surrounding the cell, the concentration of oxygen is 1.2%, and the concentration of carbon dioxide is 0.2%. Which way will the oxygen and carbon dioxide molecules move?

   Draw a picture of the situation:

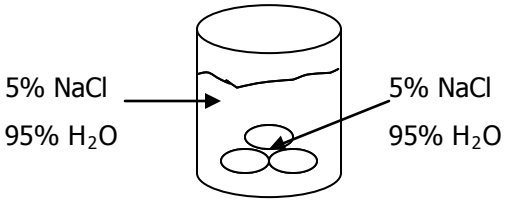
   The oxygen will move _____ of blood and _____ cells.
   The carbon dioxide will move _____ of cells and _____ blood.

2. Observe the following cell. What will happen to the molecules after a period of time?

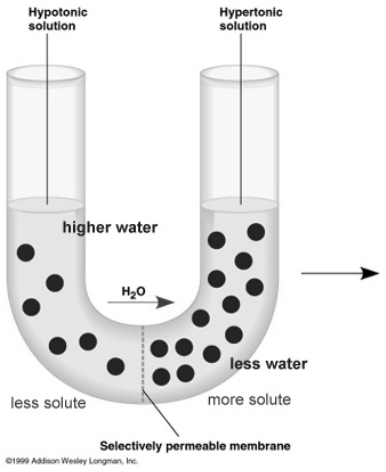


   The _____ molecules will move into the cell and the _____ molecules will move out of the cell.

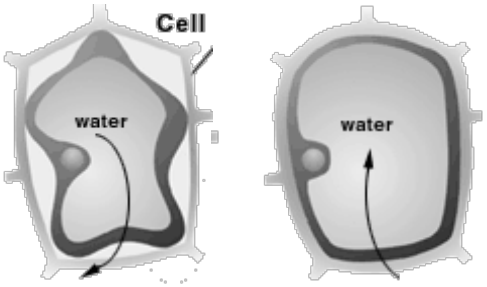
3. The following picture shows blood cells in a saline (salt) solution. Draw arrows on the picture to show which way the water will move.



4. Observe the following picture. Draw another picture in the space provided to show how water levels would change after osmosis.

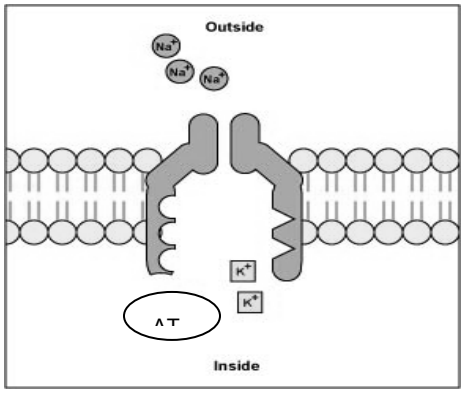


5. Below are pictures of plant cells surrounded by watery solutions. Below each picture, write if the plant cell in is a solution of "more water" or "less water".



_____ _____

6. In the picture below sodium (Na) will move **out** of the cell and potassium (K) will move **into** the cell. Will this be active or passive transport? Why?



The diagram shows _____ transport.

Explanation:

_____
_____
_____
_____

7. Identify the pictures below. What process occurs in each of these structures?

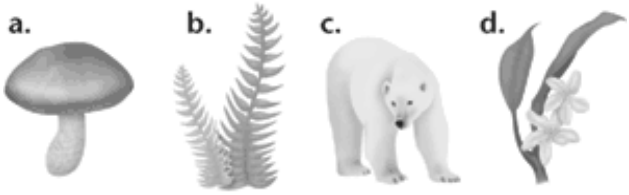
Name: _____

Process: _____

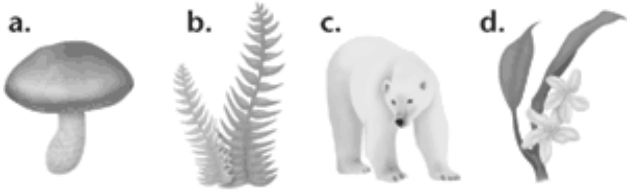
Name: _____

Process: _____

8. Which organisms perform photosynthesis?



Which organisms perform cellular respiration?



9. In making bread dough, microorganisms called yeast are used. The yeast undergo anaerobic respiration (also called fermentation), and in the process, the bread dough rises. What gas are the yeast releasing that causes the bread dough to rise?

_____

10. Write out the chemical equation for photosynthesis:

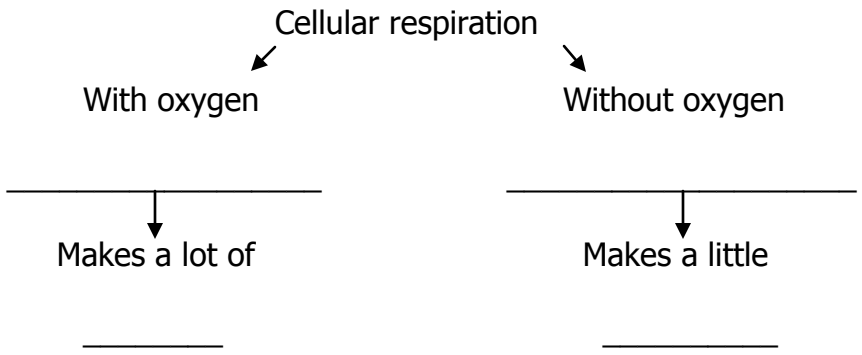
Write out the chemical equation for cellular respiration:

11. Complete the following table:

	Photosynthesis	**Cellular Respiration**
Organelle		
Types of organisms		
Reactants (what is used)		
Products (what is made)		

12. Defend the following statement:
Photosynthesis and cellular respiration are the opposite of each other.

13. Complete the flow chart below:



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http://www.scientific-art.com/GIF%20files/Medical/organell.gif
http://www.phschool.com/

Unit 2: Cellular Chemistry, Structure, and Physiology

Module 5: Cellular Reproduction

NC Essential Standard:
- 1.2 Analyze the cell as a living system
- 2.1.2 Analyze the survival and reproductive success of organisms in terms of [reproductive] adaptations

STOP!

True or False …What do you think?

1. A single cell can grow in size / mass.
2. Organisms grow by cell division, but cells do not increase in size or mass.
3. As an organism grows, the number of cells remains constant but the size of cells increases.
4. In cell division, chromosomes are divided between two cells.
5. Asexual reproduction produces "weak" organisms.
6. In asexual reproduction, half of an organism's DNA is passed to the offspring.
7. Animals and plants can reproduce sexually.
8. In sexually reproducing organisms, DNA is inherited from the same sex parent.
9. In sexual reproduction, an organism receives half of its DNA from each parent.
10. Sperm and egg do not contain the same amount of DNA as body cells.

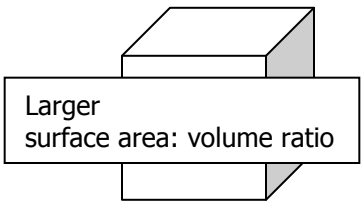
I. Why do cells divide?

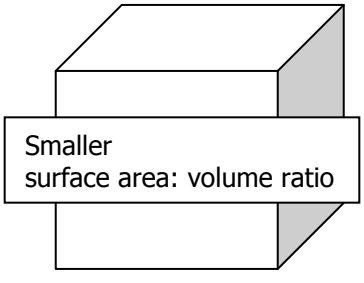
A. Cells divide to maintain a workable volume to surface area ratio

1. Volume is the amount of space inside of a cell. This would include the cytoplasm and all of the organelles.
2. Surface area is the total amount of exterior which is exposed to the environment around the cell. This would include the outside of the cell membrane.
3. Volume increases faster than surface area. The surface area must be large enough for a sufficient amount of materials to enter the cell. The materials must enter quickly enough that all of the cell will get what it needs. Thus, a larger surface area: volume ratio is preferable.

EXPLAIN which of the cell sizes pictured is preferable.

Examples:





B. Cells divide to make more cells

1. Growth of a multicellular organism requires the addition of cells. Larger organisms do not necessarily have bigger cells, but they will have more cells than smaller organisms.
2. Repair of damaged tissues by replacement of cells lost due to injury or cell death requires cell division. A healthy cell will divide to replace the lost cell(s).
3. Cell division occurs at different rates depending on the organism and the type of cell.
   a. Plant root cells would divide more rapidly because this is an area of active growth.
   b. Some nerve cells enter a phase of no division.
   c. Some bacteria cells divide very rapidly. For example, E. coli can divide every 20 minutes in ideal conditions.

2 reasons that cells need to divide:

1.

2.

II. How do cells divide?

Watch It!

A. Prokaryotic vs. Eukaryotic Division

1. The result of all cell division is the production of **daughter cells**. In order for the daughter cells to contain enough DNA, the genetic material (DNA) of the parent cell must be copied.
2. Prokaryotic division differs from eukaryotic division because prokaryotic cells do not contain a nucleus or membrane-bound organelles.
3. Eukaryotic division requires the replication of the nucleus and genetic material (DNA) as well as the allocation of the organelles into each daughter cell.

Reason that prokaryotic cell division is simpler than eukaryotic cell division…

B. Eukaryotic Cell Cycle and Mitosis

1. **Interphase** is the "normal" part of the cell cycle. The cells spend most of the cycle (life of the cell) in interphase. There are three stages in interphase

Differentiate between..
Chromatin –

Chromatid –

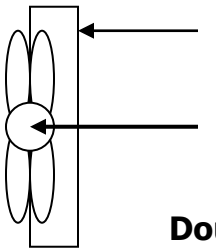
Chromosome –

a. **G_1** – Cell increases in size and synthesizes new proteins and organelles.

b. **S** – DNA is replicated.

i. During most of interphase DNA exists in a "relaxed", stringy form called **chromatin**. After being copied, there are two complete copies of the DNA in the cell. These copies are attached to each other.

ii. Each copy of DNA is called a **chromatid**. The two chromatids are attached in a region called the **centromere**. At this point in interphase, the chromatids are coiled / condensed. The entire structure is called a **doubled chromosome**.



Doubled Chromosome

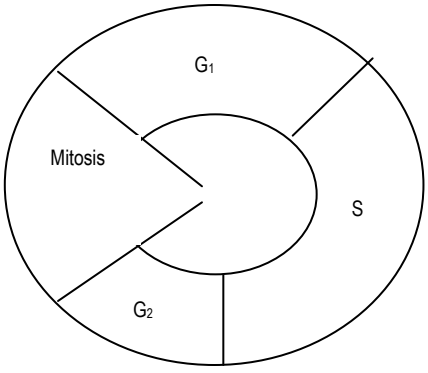
Summary of the cell cycle
1. Interphase
i.
ii.
iii.

2. Mitosis
i.
ii.
iii.
iv.

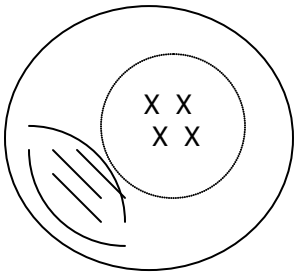
3.

c. **G_2** – Organelles and molecules required for cell division are produced

On the diagram of the cell cycle, HIGHLIGHT the stages that are part of Interphase.

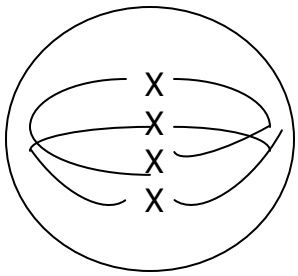


2. Stages of **Mitosis** (Eukaryotic cell division)



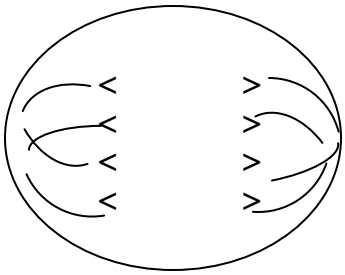
a. Prophase

- Coiled chromosomes become visible
- Nuclear membrane is broken down
- Spindles (protein fibers that will attach to chromosomes and aid in chromosome movement) start to form



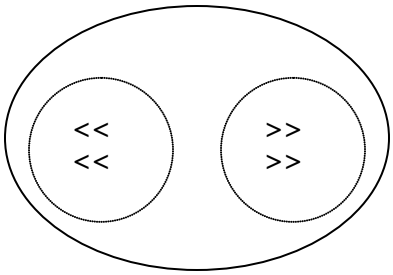
b. Metaphase

- Spindle fibers attach to the centromere regions
- Chromosomes are moved to the middle of the cell



c. Anaphase

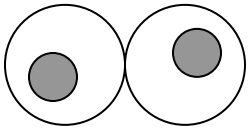
- Spindle fibers shorten
- Doubled chromosomes are separated into chromatids
- Chromatids begin to move to opposite poles/ends of the cell

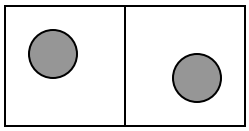


d. Telophase

- Spindle fibers are broken down
- Nuclear membrane begins to form around the clusters of chromatids at each pole of the cell

3. **Cytokinesis** is the separation of the cytoplasm (including all organelles) into two identical daughter cells.
   a. Animal cells constrict in the middle to pinch apart forming two different cells.
   b. Plant cells also produce a **cell plate** dividing the two cells. This cell plate will become the cell wall.





C. Mitosis and Cancer

Cancer is caused by uncontrolled _____ _____, which may occur because of
1.

2.

3.

1. Typically, cell division is controlled by genes in the cell, contact with other cells, and available nutrients in the environment.
2. Cancer is a class of diseases characterized by uncontrolled cell division and the ability of these cells to invade other tissues.
3. Cancer occurs when the genes that control cell division do not function properly. This may occur because of an inherited genetic defect, a spontaneous genetic mutation, or a mutation caused by environmental factors.

Check Yourself!

1. Why is a large surface area: volume ratio preferable?

2. Name three reasons cells must divide.

3. Why is eukaryotic cell division more complex than prokaryotic cell division?

4. What are the two basic stages of the cell cycle?

5. How is the genetic material "prepared" for cell division during interphase?

6. How many daughter cells are produced as a result of mitosis, and how do these cells compare to the parent cell?

7. How are mitosis and cancer connected?

III. Why does reproduction require two types of cell division?

A. Asexual reproduction and cell division

1. **Asexual reproduction** is reproduction involving only one source of genetic material (i.e. one parent). This means that offspring will be genetically identical to the parent, or **clones**.
2. There are several types of asexual reproduction:
   a. **Binary fission** occurs when a unicellular organism (such as bacteria or an amoeba) divides into two equally sized cells for the purpose of reproduction.
   b. **Budding** occurs when simple organisms (such as yeast or hydra) produce much smaller cells than those of the parent organism.
   c. **Sporulation** occurs when an organism (such as mushrooms) produce spores – tiny packets of DNA – for the purpose of reproduction.
   d. **Vegetative propagation** occurs when a portion of a plant goes through cell division in order to produce another plant.
   e. **Regeneration** occurs when a part of an animal (such as an earthworm) undergoes cell division to produce a new organism.
3. Advantages and Disadvantages of Asexual Reproduction:
   a. Advantages of asexual reproduction include speed of reproduction and producing multiple copies of successful genetic combinations.
   b. Disadvantages of asexual reproduction include increased risk of a single factor affecting an entire population due to lack of genetic variation.

Simple pictures of asexual reproduction:
Binary fission
Budding
Sporulation
Vegetative Propagation
Regeneration

4. Mitosis is usually the mechanism that allows asexual reproduction to occur. For example, when an earthworm is cut in half, cells must use mitosis to divide in order to produce cells which will reconstruct the missing portion.

B. Sexual reproduction and cell division

Picture of fertilization:

1. **Sexual reproduction** is reproduction involving two sources of genetic material (i.e. two parents). This means that offspring will be genetic combinations of the two parents.
   a. **Gametes** are sex cells, such as sperm and egg. The purpose of a gamete is to fuse with another gamete to combine genetic material (fertilization).
   b. A **zygote** is the cell which is produced by fertilization. The zygote will develop into an embryo.
2. Advantages and Disadvantages of Sexual Reproduction:
   a. The main advantage of sexual reproduction is genetic variation. With many genetic possibilities, the likelihood of a successful combination of traits for a particular environment is high.
   b. The disadvantages of sexual reproduction include the necessity of mating for fertilization (which requires more time) and the risks of unfavorable genetic combinations.

Summary:	**Advantage**	**Disadvantage**
Asexual		
Sexual		

3. Although sexual reproduction begins differently than asexual reproduction (with two parents as opposed to one parent), sexual reproduction also relies on cell division.
   a. **Meiosis** is a type of cell division which produces gametes. Meiosis is a unique type of cell division because it divides the genetic material in half, allowing for fertilization.

Example: Human body cells contain 46 chromosomes. In order for a zygote (fertilized egg) to contain 46 chromosomes, the sperm and egg must each contain only 23 chromosomes.

b. Mitosis is the process which allows the zygote to begin dividing to produce a multicellular organism. The cells also must differentiate (become different types of cells to carry out different functions).

In sexual reproduction…

Job of meiosis –

Job of mitosis -

Check Yourself!

1. How many sources of genetic material are involved in asexual reproduction?
   In sexual reproduction?

2. Name five types of asexual reproduction.

3. Why is mitosis necessary for asexual reproduction?

4. Name one advantage and one disadvantage of asexual reproduction.

5. What are gametes? How is a zygote produced from gametes?

6. Name one advantage and one disadvantage of sexual reproduction.

7. How are both mitosis and meiosis necessary for sexual reproduction?

IV. How does meiosis produce gametes?

A. Recall that a gamete is very different from a **somatic** (body) cell.

1. A somatic cell is **diploid**, which means it contains two of each type of chromosome. These chromosome pairs are called **homologous chromosomes**. For example, a human has 23 types of chromosomes. A human somatic cell has 46 total chromosomes, consisting of 23 homologous pairs.
2. A gamete is **haploid**, which means it contains only one of each type of chromosome (one from each homologous pair). For example, a human egg cell (ovum) contains 23 total chromosomes.

# of chromosomes in a human…

DIPLOID cell _____

HAPLOID cell _____

B. Eukaryotic Cell Cycle and Meiosis

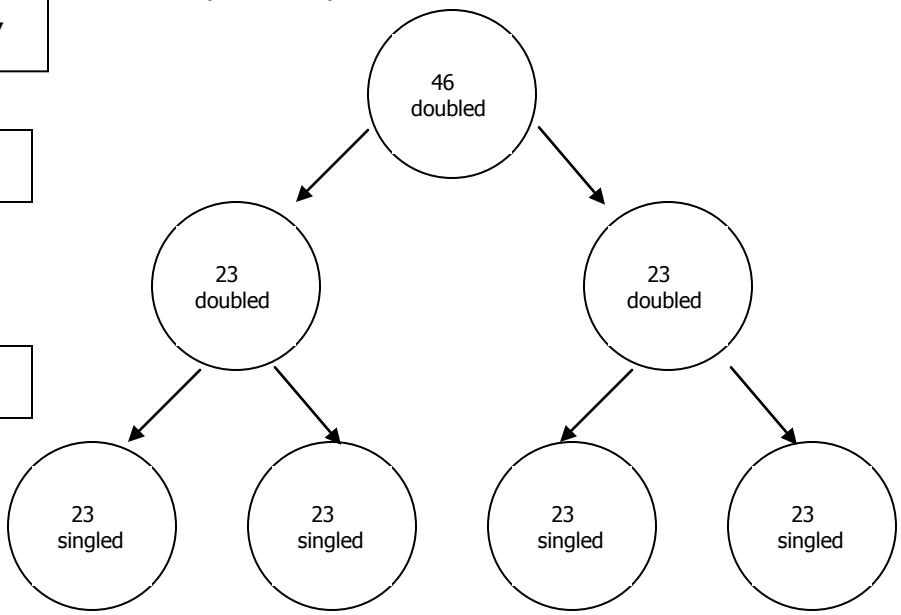
1. At the end of interphase (the longest part of the cell cycle in which the cell completes normal life functions), the cell duplicates the DNA. This creates doubled chromosomes. The cell is now ready to divide.
2. Meiosis requires two cell divisions:
   a. Meiosis I is called the **reduction division**. In this division, the homologous pairs of doubled chromosomes are separated. The end result of Meiosis I is two daughter cells, each of which is haploid but contains doubled genetic material.
   b. Meiosis II uses the same basic steps as mitosis. In this division, the doubled chromosomes are separated. The end result of Meiosis II is four daughter cells, each of which is haploid and contains no duplicated DNA.

Label each of the cells in the diagram as "diploid" or "haploid"

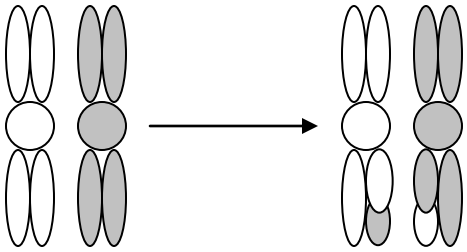
Meiosis I

Meiosis II

c. Graphical representation of Meiosis:



5. Meiosis provides several sources of **genetic variation**:
   a. **Gene mutations** can occur during the duplication of DNA at the end of interphase before meiosis (or mitosis) begins.
   b. **Crossing over** occurs when the homologous pairs come together during Meiosis I. In crossing-over a part of one chromosome can switch places with the same part of the homologous chromosome. Then, when the homologous pairs are separated, each chromosome will be different than the original.



Summary of sources of genetic variation:

1.

2.

3.

4.

5.

c. **Random assortment** of chromosomes into daughter cells during Meiosis I allows for a mix of the chromosomes inherited from each parent.
d. **Nondisjunction,** when homologous chromosomes do not properly separate, may occur during Meiosis I, creating a gamete with one too many or one too few chromosomes.
e. The **random fertilization** of any one egg by any one sperm allows for numerous genetic combinations in offspring.

Check Yourself!

1. How is the chromosome number of a gamete different from the chromosome number of a somatic cell?

2. What types of cells are diploid? Haploid?

3. What is the purpose of meiosis?

4. What is another name for Meiosis I?

5. How is the purpose of Meiosis I different from the purpose of Meiosis II?

6. Name five sources of variation meiosis provides.

7. Describe crossing-over.

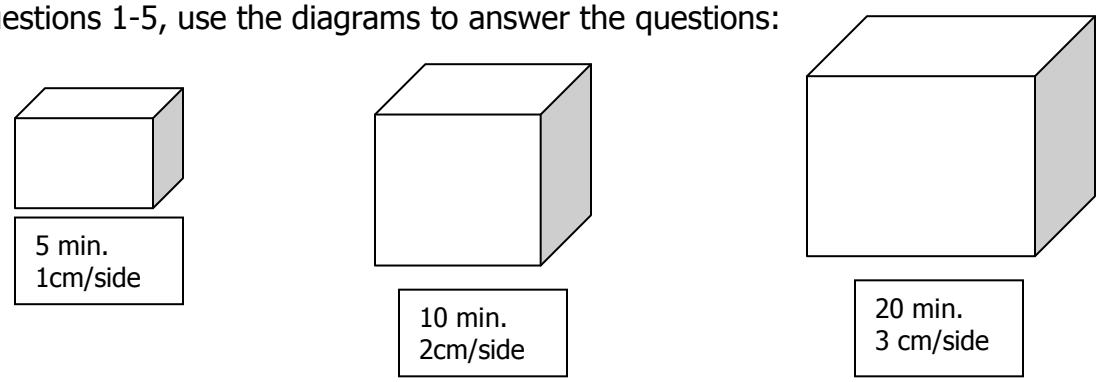
Comparing Mitosis and Meiosis

Put an "X" in a box to indicate if the statement applies to Mitosis or Meiosis. If the statement applies to both, put an "X" in both boxes.

Characteristic	**Mitosis**	**Meiosis**
A cell with 8 chromosomes would create two cells with 8 chromosomes each		
Two divisions		
Four daughter cells are produced		
Used for growth and asexual reproduction		
Used for sexual reproduction		
One division		
Two daughter cells are produced		
The chromosome number is maintained from parent to daughter cells		
Creates identical daughter cells		
No regulation of the process can lead to cancer		
Daughter cells are not identical to the parent cell		
Produces gametes		
Takes place in somatic cells		
Chromosomes move around in the cell during different phases		
DNA is duplicated before the process begins		
Type a unicellular organism would most likely use		

Unit 2 / Module 5
Problem-Solving Set

The diagrams below show a plant cell at different stages of cell growth. For questions 1-5, use the diagrams to answer the questions:



1. Surface area is calculated by the formula length x width x 6. Calculate the surface area for the cell at each time.

   a. 5 min. _____ cm^2
   b. 10 min. _____ cm^2
   c. 20 min. _____ cm^2

2. Volume is calculated by the formula length x width x height. Calculate the volume of the cell at each time.

   a. 5 min. _____ cm^3
   b. 10 min. _____ cm^3
   c. 20 min. _____ cm^3

3. What is the surface area : volume ratio for the cell at each time?

   a. 5 min. _____
   b. 10 min. _____
   c. 20 min. _____

4. At which time is the surface area : volume ratio the largest?

5. At which time will diffusion of materials into the cell be least effective?

6. On the cell diagrams shown below, OUTLINE the area that represents the surface area in blue, SHADE IN the area that represents the volume in red.

LABEL each cell with the correct surface area : volume ratio using the choices below:

a. 2:1
b. 3:1

Use the diagrams of a cell undergoing mitosis to answer questions 7 – 10:

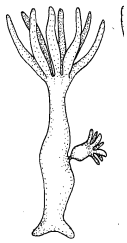
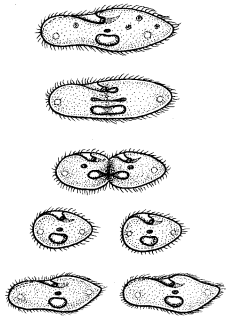
A B C D

7. What is the correct order of the cells above? ____, ____, ____, ____
8. Describe the location of the chromosomes in diagram B. _____
   _____
9. How many daughter cells will be produced in this process? _____
10. If the original cell has 4 chromosomes, how many chromosomes will be in each daughter cell? _____

11. Describe how the growth of cancerous tumors is related to mitosis.

12. Identify the type of asexual reproduction being shown:



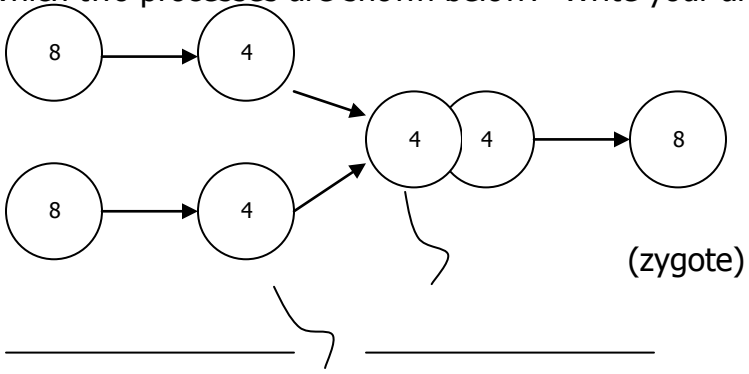




_____ _____ _____ _____ _____

13. For the chart below, place an X in the column to indicate if the statement applies to sexual or asexual reproduction. If the statement applies to both, put an "X" in both boxes.

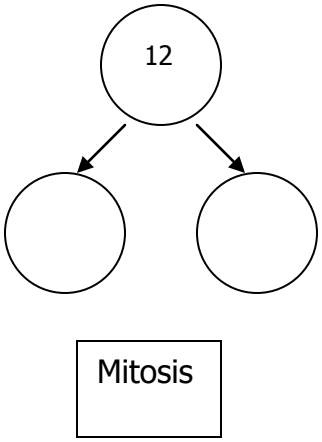
Characteristic	**Sexual Reproduction**	**Asexual Reproduction**
Produces genetically identical offspring.		
Mitosis is the mechanism which allows this to occur.		
Requires mating for fertilization of the egg.		
Two genetic sources are combined to produce offspring.		
Typically begins with meiotic division to produce gametes.		
The main advantage is genetic variation.		
Increases the size of the population.		

14. Which two processes are shown below? Write your answers on the lines.

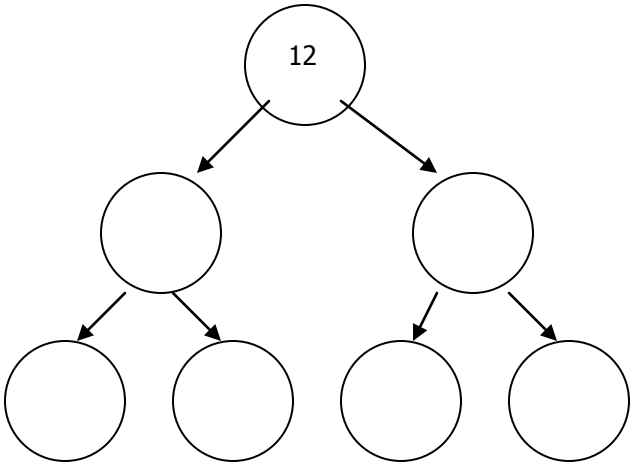


_____ _____

Use the following diagrams for questions 15 – 18



Mitosis



Meiosis

15. Using the number of chromosomes in the parent cell, write the number of chromosomes that would be found in each cell.
16. Color all diploid cells red and all haploid cells blue.
17. If this **meiotic** division was occurring in a **males** body, what type of cells would the "daughter" cells be? _____
18. Which type of cell division shown above would be used to heal a wound? _____

For questions 19-23, identify the source of genetic variation being described. Each source (gene mutation, crossing over, random assortment of chromosomes, nondisjunction, and random fertilization) will be used just once.

Description	Source of genetic variation
19.A male fruit fly produced 500 sperm cells. The female fruit fly produced 100 egg cells. Only 50 of that males sperm cells were used to fertilize 50 of the females eggs.	
20.A daughter cell of meiosis was produced with one additional chromosome (one too many)	
21.Each sperm cell produced in the male cat's body has a combination of genes from his mother cat and his father cat	
22.The DNA was not duplicated exactly before meiosis.	
23.After Meiosis I, a chromosome is different than the original	

Image Credits
http://www.biology.iupui.edu/biocourses/N100/images/8mitosiscropped.jpg
http://tonkydesigns.com/blog/wp-content/gallery/2009-random/animal-cell-diagram-wall-sticker-silo2.jpg

Unit 3: DNA and Genetics

Module 6: Molecular Basis of Heredity

NC Essential Standard
- 3.1 Explain how traits are determined by the structure and function of DNA

STOP!

True or False …What do you think?

1. Genes are traits.
2. Some organisms do not have DNA.
3. Information in the DNA of a plant or animal does not affect behavior.
4. DNA is made up of amino acids.
5. Chromosomes are made up of DNA.
6. Information in DNA affects the physical characteristics of an organism.
7. The code of DNA is determined by the order of the nucleotides.
8. There are 20 types of nucleotides.
9. Different cell types in an organism have different DNA.
10. Proteins are made up of DNA.

I. What is **DNA**?

A. Importance of DNA

1. DNA stands for **deoxyribonucleic acid**. It is one of two nucleic acids found in the cell.
2. DNA is the blueprint for life. Every living thing uses DNA as a code for making proteins which determine traits. For example, DNA contains the instructions for making special proteins (called pigments) which give your eyes color.
3. DNA is packaged in **chromosomes**. Each chromosome is composed of one continuous DNA molecule. The DNA molecule is wrapped around proteins and coiled tightly for protection.
4. Remember, chromosomes are found in the nucleus of eukaryotic cells. Prokaryotic cells have a single chromosome free-floating in the cytoplasm.

DNA

What?

Where?

Used for?

B. Discovery of DNA structure

1. Many scientists worked to determine the source of heredity. **Heredity** is the passing of **traits** from parent to offspring. But how are those traits passed?
   a. First, scientists determined that chromosomes controlled heredity and are made of DNA and proteins.
   b. Then, scientists determined DNA was the chemical that controlled characteristics (traits) of the organisms.
   c. Then, the race was on to reveal the chemical structure of the DNA molecule.
2. Rosalind Franklin was the first to take a clear "picture" of DNA using a technique called X-ray crystallography. The "picture" offered a clue to the shape of DNA.
3. Watson and Crick received credit for finalizing the model of DNA by using the picture taken by Franklin (given to them by Franklin's research assistant – Maurice Wilkins), and by synthesizing work completed by other scientists.

Watch It!

C. Structure of the DNA molecule

(From small to large)

N_____ base + sugar + phosphate

↓

N_____

↓

Two strands held by _____ _____

↓

D_____H_____

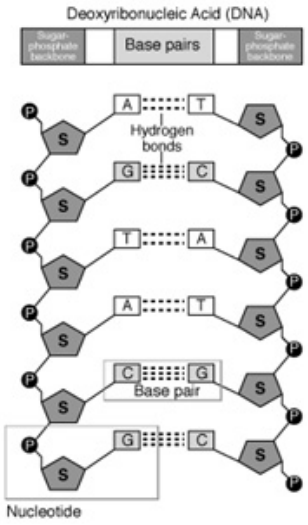
1. DNA is a **double helix**. The double helix looks like a twisted ladder.
2. The building blocks of DNA are called **nucleotides**. A nucleotide consists of three parts:
   a. A sugar (named **deoxyribose**)
   b. A **phosphate** group
   c. One of four **nitrogen bases**. The four possible nitrogen bases in a DNA molecule are named:
      i. **Adenine** (A)
      ii. **Thymine** (T)
      iii. **Guanine** (G)
      iv. **Cytosine** (C)

3. There are two strands of nucleotides in every DNA molecule held together by weak **hydrogen bonds** that occur in the middle between the nitrogen bases.
4. The nitrogen bases bond in a specific way. Adenine bonds with thymine (A–T). Guanine bonds with cytosine (G-C). This pattern is called **complementary base pairing**.

On this diagram, highlight a nucleotide.

Then write out the NAME of the sugar beside one of the sugar molecules.

Finally, draw a box around the "backbone" and label.



coris.noaa.gov/glossary/ nucleotide_186.jpg

Check Yourself!

1. How is DNA connected to your traits?

2. What larger structure is composed of DNA?

3. What two parts of the nucleotide make up the sides (backbones) of a DNA molecule?

4. What makes up one rung/ "step" of the DNA "ladder"?

5. What type of bond holds the rungs together?

II. Do all my cells have the same DNA?

Watch It!

A. **DNA replication** copies DNA for new cells

1. DNA is needed in each cell to make necessary proteins.
2. Because DNA is so important, when a cell divides, it must pass on an <u>exact</u> copy of the DNA to function correctly.
3. Therefore, DNA is copied (replicated) during the S phase of the cell cycle (part of interphase, before mitosis/meiosis).

B. Process of DNA replication

1. An enzyme breaks the weak hydrogen bonds between the paired nitrogen bases. This allows DNA to "unzip" as the two strands move apart.
2. The newly unpaired nucleotides are paired (A-T and G-C) with extra nucleotides present in the nucleus. This process is catalyzed by another enzyme.
3. Enzymes then link the nucleotides along the newly constructed side of the DNA ladder by bonding sugar to phosphate.
4. The DNA is proofread by enzymes for any errors.

Enzyme Review!
What <u>are</u> enzymes?

How do enzymes work?

C. Result of DNA replication

1. Two identical DNA molecules have been produced. Each "daughter" DNA molecule is composed of one "old" strand and one "new" strand. (Here a "strand" refers to one chain of nucleotides.)
2. Each copy of DNA is packaged as a chromatid on a doubled chromosome.
3. After mitosis, each daughter cell will receive one of the two identical copies of DNA. This happens when the doubled chromosome is split, each new chromosome going to a new daughter cell.

Replication
What?

Where?

Used for?

When?

Check Yourself!

1. Why does each cell need DNA?

2. What is the name of the process which makes a copy of DNA?
3. When does DNA replication occur?
4. What catalyzes each step of DNA replication?
5. At the end of DNA replication, each molecule is composed of one _____ strand and one _____ strand.

III. How can DNA be used by the cell to make a protein?

A. Importance of **protein synthesis**

What is a trait?

How are the terms "protein" and "trait" related?

1. Every inherited trait is controlled by one or more proteins. Protein synthesis is the process that makes those proteins.
2. Each cell must produce different proteins, based on the function of that cell. For example, only blood cells need to produce the protein hemoglobin.

B. Central Dogma of Biology – the central axis around which all other biological concepts rotate

1. DNA structure controls the production of proteins.
   a. A section of DNA which is used as the blueprint or code for the production of a protein is a **gene**.
   b. Each gene is composed of a specific sequence of nucleotides. This sequence can be represented by writing the order of nitrogen bases. For example, ACGCCATGCTAC
   c. Every three bases in this sequence is called a **codon**. A codon is like a single word in a sentence. Only by putting the words (codons) in the correct order can you create a meaningful sentence (protein).

Three DNA nucleotides makes a _____.

One codon controls the placement of one _____ _____.

Many amino acids make a _____.

Rewrite the "Central Dogma" as a sentence (use all of the words!)

d. Proteins are made of amino acids. Each codon directs the cell to place a specific amino acid in a particular position as the protein is built. For example, the codon CAA in DNA codes for the amino acid "valine". If this codon was the third codon in a gene, valine would be the third amino acid in the protein.

2. Diagram of the Central Dogma

DNA ----------→ RNA ----------→ Protein
(transcription) (translation)

C. Process of protein synthesis

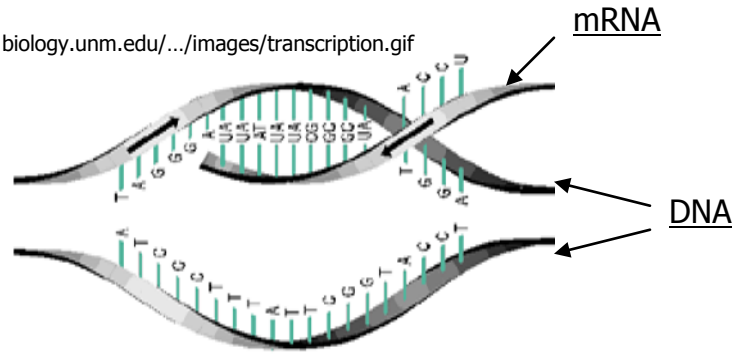
1. **Transcription** rewrites the DNA code as messenger RNA
   a. DNA cannot leave the nucleus (it is far too big) to go the ribosomes where proteins are made. Thus, it must send the instructions using RNA.
   b. **mRNA** copies the DNA when the DNA unzips one section called a gene. One gene makes one protein.
   c. **messengerRNA** is constructed one nucleotide at a time using one side of the DNA as a template.
   d. All RNA has a different sugar (**ribose**) which cannot bond to thymine. Thus, RNA must use a different nitrogen base (**uracil**) as a substitute for thymine (T). If the DNA read CTA, the mRNA would be GAU.
   e. mRNA leaves the nucleus through a small opening in the nuclear membrane called a pore.
   f. The DNA rezips the gene.

How does transcription produce a "script" based on DNA?

Highlight the mRNA.

Explain this diagram.

biology.unm.edu/…/images/transcription.gif



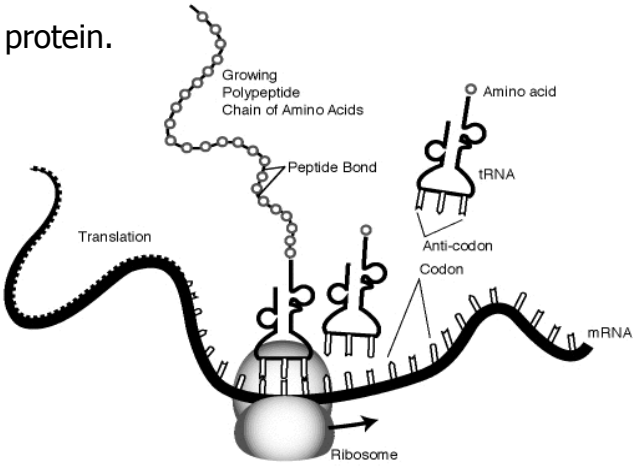
How does translation "read" the "script" produced in transcription?

Watch It!

2. **Translation** uses the mRNA to build a protein
   a. In the cytoplasm of the cell, translation occurs at the ribosome. Ribosomes are made of **rRNA** (**ribosomal RNA**) and proteins.
   b. The mRNA "start" codon (AUG) attaches to the ribosome. The ribosome holds mRNA and helps link amino acids together to make a protein.
   c. **tRNA** (**transfer RNA**) is a molecule that carries an amino acid to the ribosome. In order for the tRNA to leave the amino acid at the ribosome, the tRNA must bond with a complementary codon on the mRNA.
   d. The ribosome allows the **tRNA anticodon** (made of three bases at the bottom of each tRNA) and the complementary mRNA codon to pair.
   e. The amino acid is removed from the tRNA by an enzyme. As each new amino acid arrives on a tRNA, amino acids are bonded together IN ORDER by a **peptide bond** to form a **polypeptide**.
   f. When the ribosome reaches a "stop" codon, it releases the mRNA and the string of amino acids separately. The string of amino acids folds and coils to shape the protein.

Highlight the protein.

Explain this diagram.



www.wikipedia.org

What is the END RESULT of protein synthesis?

3. Result of protein synthesis
   a. Cells respond to their environments by producing different types and amounts of protein.
   b. The cell produces proteins that are structural (forming part of the cell materials) or functional (such as enzymes, hormones, or chemicals for in cell chemistry).
   c. All of an organism's cells have the same DNA, but the cells differ based on the expression of the genes.
      i. Multicellular organisms begin as undifferentiated masses of cells. Variation in DNA activity determines cell types.
      ii. Different types of cells expressing different genes leads to **differentiation**. Only specific parts of the DNA are activated in those cells. Once a cell differentiates, the process cannot be reversed. For example, we have muscle cells, nerve cells, and others.
      iii. **Gene regulation** is the process which determines which genes will be expressed (used to make a protein). This can be affected by the cell's history and/or environment. Proteins may be overproduced, underproduced or produced at incorrect times. Ex: Injury repair and cancer
   d. Each individual in a sexually reproducing population has slightly differing sequences of nucleotides in DNA when compared to other organisms of the same specie. The different sequences lead to different proteins, which produce different traits (i.e. variation). For example, two humans with different eye color.

Watch It!

If gene regulation were not possible, would cell specialization happen?

Why/why not?

Check Yourself!

1. What controls inherited traits?
2. What controls the production of proteins?
3. Define a gene.
4. Diagram the central dogma of biology.
5. What is the purpose of transcription?
6. What type of RNA is used in transcription?
7. What nitrogen base in RNA is used as a substitution for thymine?
8. What is the purpose of translation?
9. What two types of RNA are used only in translation?
10. What type of bond links amino acids?

IV. Whth appensw henp roteins ynthesisg oesw rong_?

Why does a change in DNA mean a change in the protein could happen?

A. A **mutation** is a change in the original DNA sequence, which may lead to a change in the amino acid sequence.

B. A mutation occurs when the original DNA sequence is not copied properly during replication or protein synthesis. Mutations can be spontaneous or caused by radiation and/or chemical exposure.

C. The result of a mutation is a change in the amino acid sequence. The necessary protein may not be made or is defective. This can change the traits of the cell or organism. Only mutations in sex cells (egg and sperm) or in the gamete can result in heritable changes.

Watch It!

D. There are two types of gene mutations:

1. **Point** (or **substitution**) mutations occur when a single base is replaced with a different base. (For example, A is replaced with C.)

   Ex. GATTACA → GAGTACA

a. A point mutation, if it occurs on a gene, may result in the change of a single amino acid within the protein.
b. Sickle cell anemia, a disease that results in misshapen red blood cells, is caused by a point mutation.

2. **Frameshift** mutations occur when a single base is added (**addition** frameshift) or deleted (**deletion** frameshift) within the sequence. Because DNA and the mRNA copy are read three bases (a codon) at a time, this type of mutation "shifts" the reading frame.

Ex. GAT/TAC/ATT → GAT/TAA/CAT/T

a. The effect of a frameshift depends on the location of the addition or deletion. The earlier within the gene sequence the base is added or deleted, the more amino acids will be changed.
b. Huntington's Disease, a disease that results in the progressive loss of nervous system function, may be caused by the insertion of several bases.

Compare/Contrast point and frameshift mutations using a Venn or T-chart:

Check Yourself!

1. Define mutation.

2. What is the result of a mutation?

3. What are the two types of mutation?

4. What type of mutation is illustrated in the title of this section of notes (IV)?

5. Which type of mutation may affect a greater number of amino acids?

DNA's Two Jobs

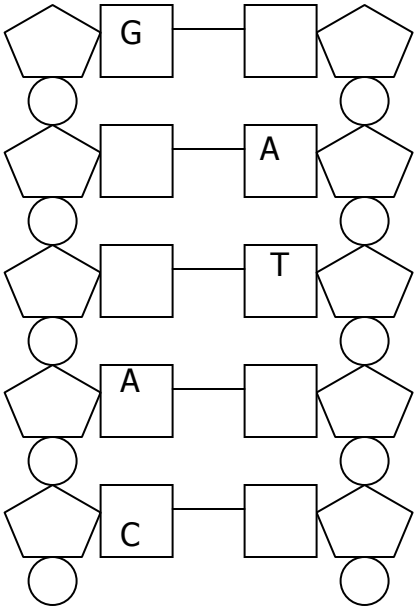
Replication	Both	Protein Synthesis
• Takes place in the _____ • Occurs before _____ _____ • Produces two _____ strands of DNA • Uses the entire _____ _____	• Uses DNA • _____ needed • Can produce _____	• Takes place in the _____ and cytoplasm (_____) • Occurs during the ____ _____ of the cell • Produces _____ • Uses a section of the DNA molecule called a _____ • Uses 3 types of _____(rRNA, mRNA, tRNA)

Word Bank:

Cell Division	Gene	Normal life	Proteins
DNA molecule	Identical	Nucleus	RNA
Enzymes	Mutations	Nucleus	Ribosome

Unit 3 / Module 6
Problem-Solving Set

1. On the DNA diagram below:
    a. Place an S in each shape that indicates sugar (deoxyribose)
    b. Place a P in each shape that indicates phosphate
    c. Complete the missing nitrogen bases
    d. Write an HB on a line that represents a hydrogen bond
    e. Draw a box around one nucleotide



2. Every living organism has DNA. ALL DNA is made of 4 types of nucleotides. What makes human DNA different from oak tree or frog DNA?

3. A molecule of DNA is analyzed for its adenine content and is found to contain 22% adenine. What is the content of the other 3 nitrogen bases?

    Adenine – 22%

    Thymine - _____

    Guanine - _____

    Cytosine - _____

4. Put the steps of DNA replication in the correct sequence:

   _____ Free nucleotides pair with newly unpaired nucleotides

   _____ The DNA molecule "unzips"

   _____ Enzymes break hydrogen bonds

   _____ Enzymes "re-zip" the DNA molecule

   _____ Two identical molecules of DNA are complete

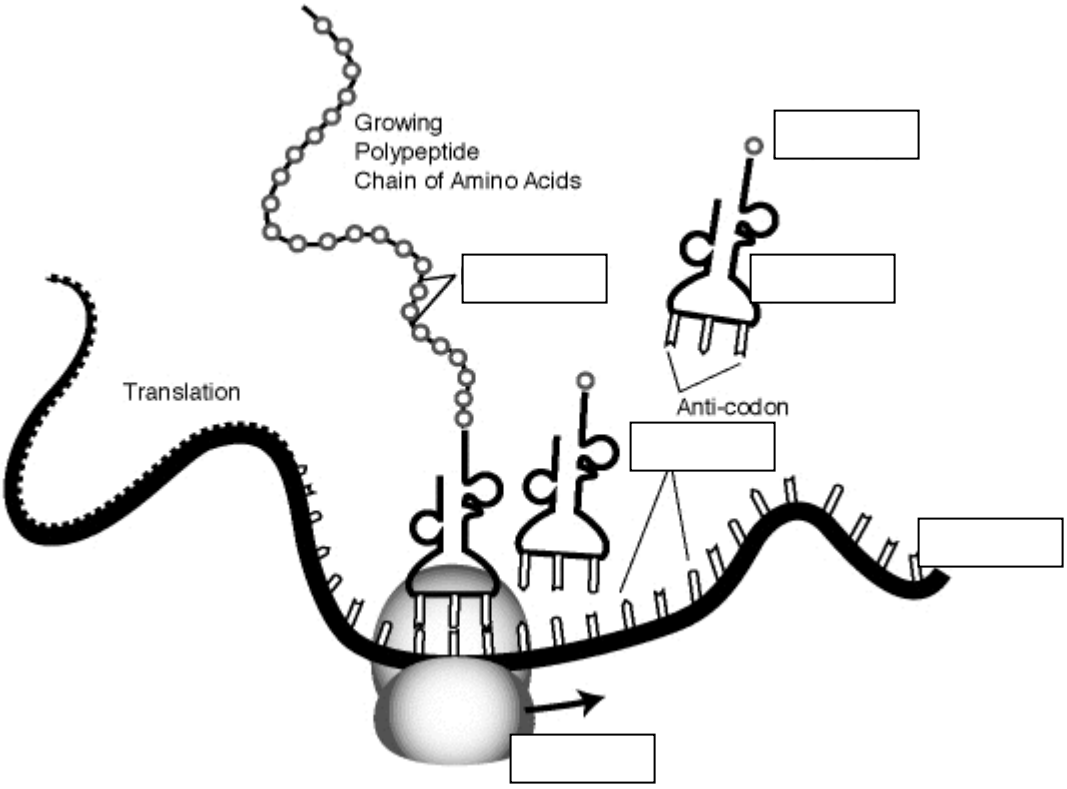
5. In the sequence below, what is the molecule labeled "A"? The molecule labeled "B"?

   A ----------→ B ----------→ Protein
   (transcription) (translation)

   A = _____ B = _____

6. Label the diagram of Protein Synthesis using the following terms:

   Ribosome mRNA tRNA Codon Amino acid Peptide bond



mRNA codon chart:

First Letter	Second Letter				Third Letter
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	stop	stop	A
	leucine	serine	stop	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	(start) methionine	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G

7. Use the mRNA codon chart to determine the amino acid sequence for the DNA sequence below.

   DNA – TAC GCT CAC AAA CGC ATC

   mRNA - _____ _____ _____ _____ _____ _____

   tRNA - _____ _____ _____ _____ _____ _____

   amino acids - _____ _____ _____ _____ _____ _____

8. Use the mRNA codon chart to determine the codons that would code for the amino acid tyrosine.

   _____ or _____

9. If the mRNA sequence reads UCACCUACGGUG, what is the sequence of DNA that it was transcribed from?

   DNA - _____

An original gene sequence in DNA reads TACGTTCCCGAT.

10. Transcribe the above sequence to mRNA:

    ____

    Use the mRNA codon chart to determine the amino acid sequence coded for:

    __________ __________ __________ __________

11. Re-write the DNA sequence assuming that a point mutation has occurred and the first G in the sequence is replaced with a T:

    ____

    Transcribe the DNA sequence into mRNA:

    ____

    Use the mRNA codon chart to determine the amino acid sequence coded for:

    __________ __________ __________ __________

    How did the point mutation affect the polypeptide chain?

12. Rewrite the DNA sequence assuming that a frameshift mutation has occurred and the first C in the sequence is deleted.

    ____

    Transcribe the DNA sequence into mRNA:

    ____

    Use the mRNA codon chart to determine the amino acid sequence coded for:

    __________ __________ __________

    How did the frameshift mutation affect the polypeptide chain?

13. ABCDE → ABFDE illustrates a _______________ mutation.

14. ABCDE → ABCFDE illustrates a _________________ mutation.

Unit 3: DNA and Genetics

Module 7: Biotechnology and Genomics

NC Essential Standard:
- 3.3 Understand the applications of DNA technology

STOP!

True or False …What do you think?

1. DNA is located in blood cells, but not any other type of cell.
2. Different cells from an organism contain different DNA.
3. A child has all of the DNA of his/her father and all of the DNA of her/his mother.
4. DNA fingerprinting occurs when police use ink to "fingerprint" suspects.
5. Genetic engineering can be used to remove existing genes.
6. Genetic engineering directly affects protein synthesis.
7. Genetic engineering allows us to put a gene from any species into another species to have that trait expressed in exactly the same manner as in the original species.
8. As a result of the Human Genome Project, we know the location of each gene in the human genome.
9. The Human Genome Project is a project designed to make it possible for humans to choose desired traits for a baby.
10. Adult stem cells come from adults and embryonic stem cells from unborn children.

I. How can we use DNA to help humans?

A. DNA Fingerprinting

Compare a DNA fingerprint with a typical fingerprint:

1. Each individual (except clones and identical twins) has a unique DNA sequence. This sequence can be used to produce a **DNA fingerprint**, a unique band pattern of DNA fragments.
2. A DNA fingerprint is produced using a gel electrophoresis. A **gel electrophoresis** is a machine that separates pieces of DNA based on size (the number of base pairs).
3. The process of producing a DNA fingerprint can be described in three basic steps:
   a. A **restriction enzyme** is used to cut the DNA sample into pieces. A restriction enzyme binds to a specific sequence of DNA bases, called a restriction site, and

cuts (cleaves) the DNA between two of the bases in that site. This produces many pieces of different sizes.

b. Once the restriction enzymes have recognized all the restriction sites and have cleaved the DNA into pieces, the sample is loaded into a **gel** for electrophoresis. Electricity forces the DNA pieces to move through the gel. Smaller pieces are able to move farther than larger pieces. The electrophoresis creates a separation of pieces by size – making a column of bands.

c. The DNA sequence of different individuals will have different numbers of restriction sites, or restriction sites in slightly different places. The variation of restriction sites means that an individual's band pattern will likely be different from other individuals. By comparing band patterns, we can determine many things.

4. DNA fingerprints can be used for several applications.

a. A DNA Fingerprint can be used to identify an individual, or determine the source of DNA left at a crime scene. Example:

A bloody knife was found a short distance from a murder victim. Two suspects have been identified:

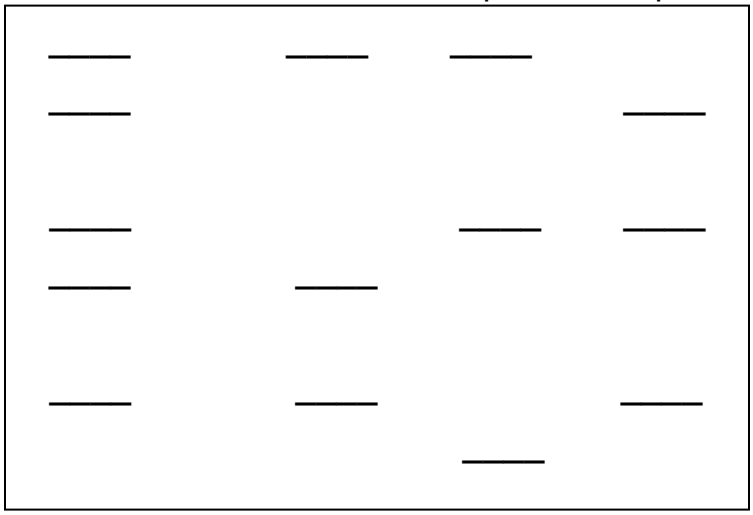
Find ONE WORD that describes each of the three steps of making a DNA fingerprint. A hint is given! Write the word below:

1. C_____

2. E_____

3. C_____

Blood on Knife | Victim | Suspect A | Suspect B



Highlight the shortest piece of DNA in this fingerprint.

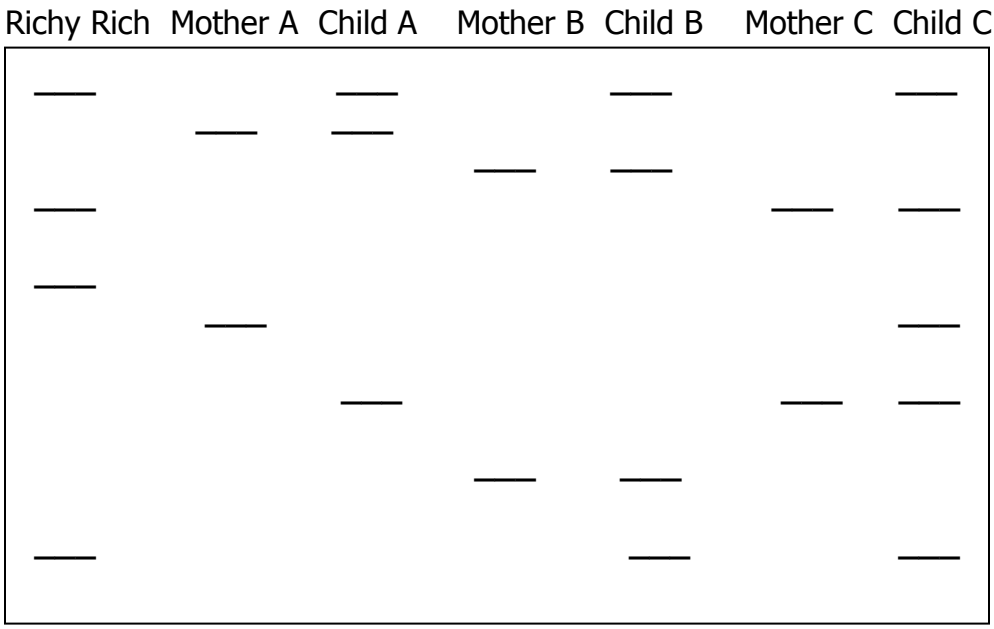
What tool/process was used to create this fingerprint?

Explanation: The blood on the knife came from two sources – the victim and another person (we can eliminate the bands of the victim, but other bands remain). By comparing the remaining bands, it is clear that Suspect A is cleared, and Suspect B is … suspect.

b. A DNA Fingerprint can be used to determine paternity.

Example:

A millionaire has been charged with several paternity cases. His lawyers ordered DNA Fingerprints:



How is analyzing a DNA fingerprint for paternity DIFFERENT than analyzing a fingerprint to identify an individual's DNA from a crime scene?

Explanation: Because half of your DNA is inherited from your mother and half from your father, each band in a child's pattern will also appear in either the pattern of the mother or of the father. Child A could NOT be Richy Rich's child because of the third band in the child's pattern. Child C could NOT be Richy Rich's based on the third band in the child's pattern. Child B COULD be Richy Rich's child.

c. DNA fingerprinting can be used to catalog endangered species. For example, researchers have developed DNA banks of endangered species protected by law. This allows them to prove if endangered species are used in products, such as medicines or foods.

Check Yourself!

1. What is a DNA Fingerprint?

2. What technology is used to make a DNA Fingerprint?
3. What type of enzymes are used to cut DNA?
4. What are three uses for DNA fingerprinting?

B. Genetic Engineering

1. **Genetic engineering** is the modification of DNA. Modification means changing, such as adding or removing parts of the DNA sequence.
2. Genetic engineering may be used to produce a **transgenic** organism (an organism containing foreign DNA) to use in gene therapy or gene cloning.
3. Genetic engineering can be used for several applications:
   a. Genetic engineering to create a transgenic organism.
      i. Restriction enzymes are used to cleave the foreign DNA source in order to isolate the desired gene. For example, removing the insulin gene from human DNA.
      ii. The same restriction enzyme is used to cleave the vector (which may be a bacterial plasmid). A **vector** is the structure used to carry the foreign DNA.

WORD HELP!

"trans" means to _____

"genic" means _____

How are each of the words related to genetic engineering?

1. Vector –

2. Recombinant DNA –

3. Host cell –

iii. The foreign DNA fragment (the desired gene) and the vector are combined/spliced together. The combination is possible for two reasons. First, DNA is similar in all organisms. Second, the same restriction enzyme is used on both samples of DNA.

iv. The combined DNA (called **recombinant DNA**) is inserted into the **host** (which may be a bacteria cell). The host cell will copy/clone the recombinant DNA as it reproduces and will produce the protein (such as insulin) from the desired gene during protein synthesis.

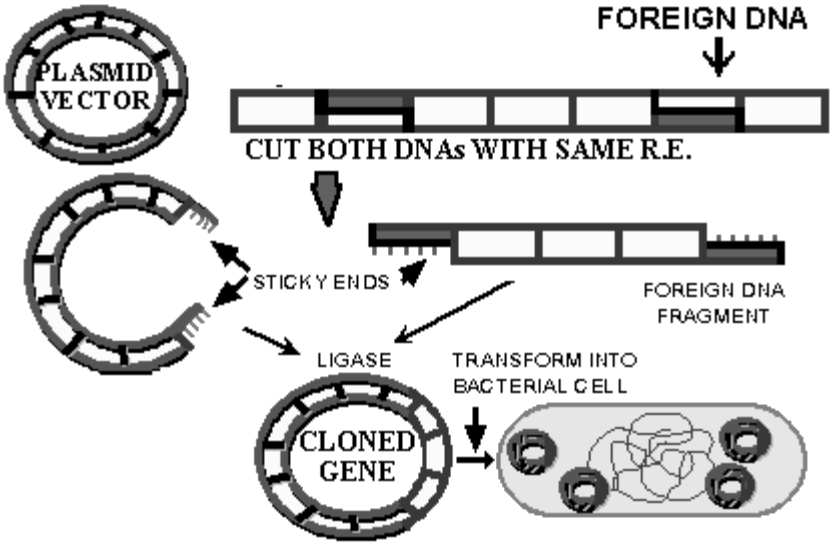
Find ONE WORD that completes the short description of each of the four steps. A hint is given! Write the word below:

1. C_____ DNA

2. V_____ opened

3. C_____ together

4. I_____ into host



b. Genetic engineering may be used for **gene therapy**. Gene therapy has been used to treat Severe Combined Immunodeficiency (SCID) and cystic fibrosis (CF). It has been shown to be safe for up to 10 years to treat SCID, but patients have the risk of developing leukemia. In treating cystic fibrosis, the results have

been limited because the patient's immune system is fighting off the virus used to carry the correct gene to the target cells.

i. Defective genes are identified within the DNA sequence. Individuals may be tested for the presence of the defective gene (for example, the IL2RG gene in SCIDS).

ii. A functioning gene, isolated from a donor's DNA is "packaged" into a vector/carrier (such as a cold virus used for CF gene therapy).

iii. The vector is introduced to the organism with the defective gene. The functioning gene is delivered to target cells and randomly inserts itself into the DNA (this is what likely caused the leukemia in the SCID treatment). Now the cell can produce the correct protein.

4. Genetic engineering has many practical purposes.
   a. Medical applications include producing large quantities of human proteins (such as insulin and human growth hormone) cheaply and providing animal models of human genetic diseases (such as knock-out mice).
   b. Agricultural applications include producing plants that are herbicide or pest resistant and plants that have higher nutritional value. These plants are commonly called GMOs (genetically-modified organisms).
   c. Industrial uses include using microorganisms to clean up mining waste, sewage treatment, and environmental disasters.

Watch It!

5. Genetic engineering raises serious bioethical concerns.
   a. The question may need to be "Should we?" instead of "Could we?" For example, should we alter the natural variation of human genes by genetic engineering?
   b. Creating plants with new genes may trigger allergic reactions. For example, adding a gene from a peanut plant to a corn plant in order to increase nutrition may cause an allergic reaction in some people.
   c. Creating organisms that are not naturally occurring may create problems in the environment or for humans. For example, an oil digesting bacteria may get into oil-based machinery and our oil supplies.

Check Yourself!

1. What is genetic engineering?
2. What is a transgenic organism?
3. How are restriction enzymes used in genetic engineering?
4. What is gene therapy?
5. List two practical applications of genetic engineering.

II. How do we know where human genes are located on chromosomes?

How is the Human Genome Project like creating a map of the world?

A. The **Human Genome Project** (HGP) is a collaborative effort among scientists around the world to map the genes of a human.
B. The purpose of the HGP was to identify the location and sequence of genes on chromosomes to better understand human genetics.
C. A primary application of the Human Genome Project is to determine whether individuals may carry genes for genetic conditions such as sickle cell anemia. Once scientists determine the location and DNA

sequence of the defective gene, they may be able to develop gene therapy or genetically based medicines to correct the condition.

D. The Human Genome Project raises serious bioethical questions.
    1. The HGP has allowed for the development of **genetic screening**. For example an individual can be tested for the presence of a gene that may contribute to breast cancer. Should the patient be notified of the presence of this gene, even though the presence of the gene does not guarantee breast cancer and may change the way they live their life? Should insurance companies be able to require genetic testing before they will insure people?
    2. The HGP has identified the location of genes. Research is now focusing on the function of those genes – including those controlling physical traits. Should humans be able to use the results of the HGP to create "designer babies"?
    3. The HGP has allowed scientists to determine DNA sequence of genes important to medicine. Should pharmaceutical companies be allowed to patent gene sequences for use only within their company?

III. Are stem cells the next "big thing" in genetic research?

A. **Stem cells** are unspecialized cells that continually reproduce themselves. These cells have the ability to differentiate into one or more types of specialized cells. Scientists hope to learn to control that differentiation.

B. There are two basic types of stem cells:
    1. **Embryonic stem cells** are cells found in an embryo that have not yet differentiated into various cell types. These cells are taken from eggs that are fertilized *in vitro* and then donated for research.
    2. **Adult stem cells** (sometimes called somatic stem cells) are found in the organs and tissues of an organism that

can renew itself. These cells can differentiate to yield some or all of the major cell types of that tissue or organ. These are more limited than embryonic cells.

C. Stem cell research, though very controversial, is a very active area of research. Scientists have recently demonstrated that stem cells, both embryonic and adult, differentiate into one or more types of cells in a lab. There are several potential applications of stem cells:

Watch It!

1. Learning how to control cell differentiation to treat cancer
2. Using stem cells to test new drugs on many cell types by creating those cell types in a lab with stem cells
3. Stem cells, directed to differentiate into specific cell types, may allow a source of replacement cells to treat diseases like Alzheimer's, spinal cord injuries, stroke, and diabetes.

D. Ethical concerns about stem cell research center around the source of stem cells. A significant number of people believe removing cells from an embryo, whether or not the embryo is formed in a lab, is destroying human life. This raises an ethical question about when life begins, and whether it is ethical to sacrifice that life (if it has begun) to potentially save another life via research or cell-based therapies.

Check Yourself!

1. What is the Human Genome Project?

2. Name two uses of the Human Genome Project?
3. What is a stem cell?
4. What are the two types of stem cells?

Genetic Engineering

Recombines

DNA

from

___different species

requires

3 steps

___/cut gene of interest

using

_____

to

Cut open bacterial _____

Remove desired _____

_____/"glueing" DNA

To make

_____

_____

of

A _____ (plasmid or virus)

To place

Recombinant DNA into a host cell (now _____)

Which allows

_____ and _____ of gene

Used to make

Human growth hormone

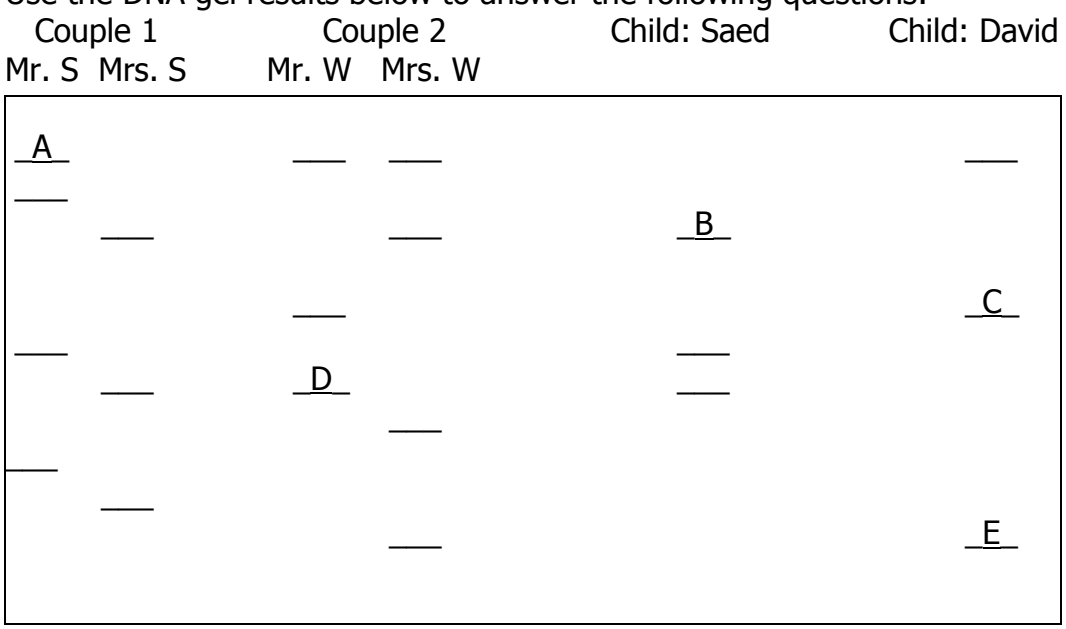
Insulin

Word Bank:

2	Recombinant DNA
Cleave	Replication
Expression	Restriction Enzyme
Gene	Splice
Insert	Transgenic
Plasmid	Vector

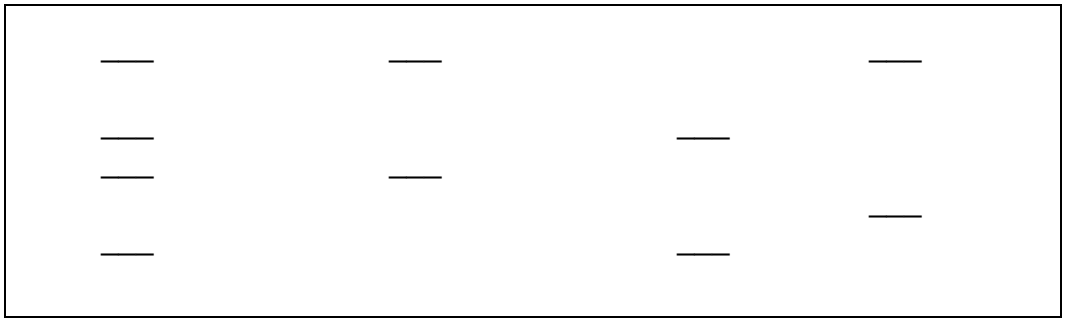
Unit 3 / Module 7
Problem-Solving Set

1. Use the DNA gel results below to answer the following questions:



   a. Of the labeled pieces (A, B, C, D, E) which piece is the longest fragment? _____
   b. How many fragments of DNA does Mr. W have? _____
   c. Which couple are the most likely parents of David? _____
   d. Which couple are the most likely parents of Saed? _____

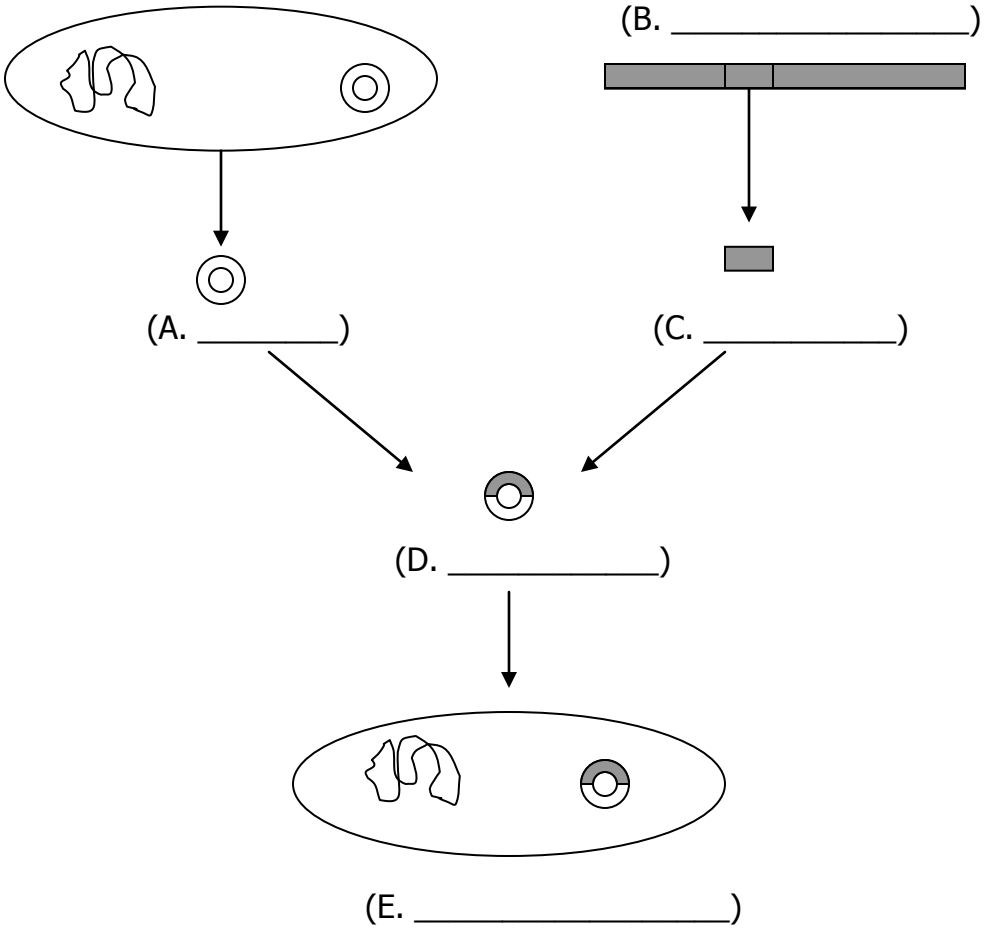
2. Use the DNA gel results below to answer the following questions:



   a. Does it appear that the crime scene DNA sample may contain DNA from the victim? How do you know?

   b. Which suspect was more likely at the crime scene? How do you know?

3. Label the following diagram with the words below. Parentheses indicate places you need to label. Then, answer the questions.
   Word Choices:
   Desired gene Transgenic Organism
   Foreign DNA Vector
   Recombinant DNA



   a. A bacteria cell provided the vector. What is the name for this particular kind of vector? _____
   b. What will happen to the vector when the bacteria cell divides using binary fission? _____
   c. What chemical "tool" was used to cut out the desired gene and open the vector? _____
   d. If the desired gene in this diagram was human growth hormone, would the bacteria cell be able to produce the human growth hormone being engineered? Why/why not? _____
      _____
      _____

4. What do you think? For each of the following statements, circle the number that best describes your response. Then, use the underlined terms in each statement to describe YOUR stance on the issue. Make sure you use ideas and concepts we have discussed in this unit and write in complete sentences!
   a. DNA fingerprints are very reliable and should be used as evidence in criminal cases and to determine paternity of children.

   Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
   1 2 3 4

   Response: _____
   _____
   _____
   _____

   b. Using genetic engineering to make transgenic organisms is necessary to produce human proteins, such as insulin, for people who cannot produce the proteins.

   Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
   1 2 3 4

   Response: _____
   _____
   _____
   _____

   c. Producing plants that are pest resistant and have higher nutritional value by using genetic engineering does not outweigh the risks of GMO's, such as possible allergic reactions.

   Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
   1 2 3 4

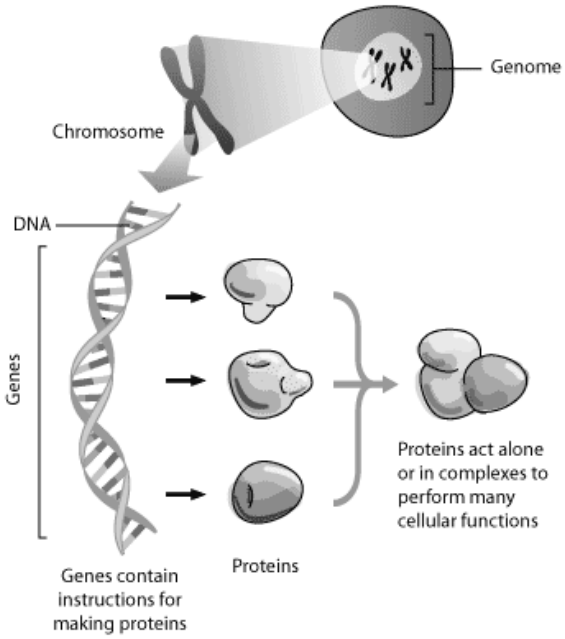
   Response: _____
   _____
   _____
   _____

   d. People should be able to use the information discovered by the Human Genome Project to select physical traits of offspring and create designer babies.

   Do NOT agree → Unsure → Agree Somewhat → Agree Strongly (Circle one.)
   1 2 3 4

   Response: _____
   _____
   _____
   _____

5. The Human Genome Project mapped the genes on each chromosome. This is important to understand human genetics. Use the diagram below to explain HOW mapping the genes on a chromosome can help us understand how the human body works.

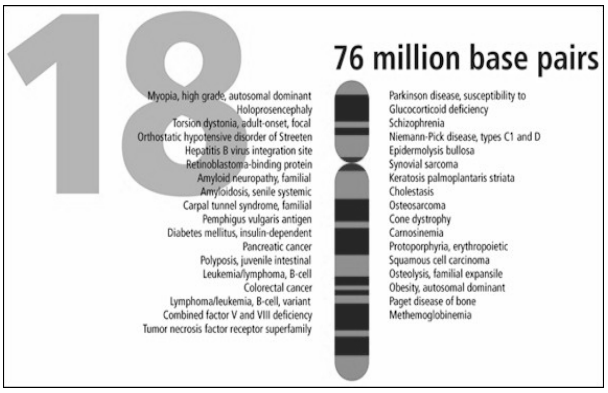


Explanation of Diagram:

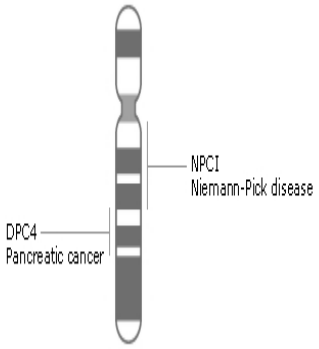
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

(picture credit: http://www.scq.ubc.ca)

6. Below is a map of Chromosome 18 with all of the currently identified genes and a similar map showing the location of two of those genes: **Color or highlight the area identified as a gene contributing to pancreatic cancer on the gene map to the left**.



(picture credit: www.genome.gov)



(Picture credit: http://www.ncbi.nlm.nih.gov)

7. List two ways embryonic stem cells and adult stem cells are different (a, b). List one way they are similar (c).
   a. _____
   b. _____
   c. _____

Unit 3: DNA and Genetics

Module 8: Genetics

NC Essential Standard:
- 3.2 Understand how the environment, and/or the interaction of alleles, influences the expression of genetic traits.

STOP!

True or False …What do you think?

1. Daughters inherit most of their traits from their mothers; boys inherit most of their traits from their fathers.
2. Each chromosome only has one gene.
3. If you have a gene for a trait, you will definitely express that trait.
4. A parent passes a copy of all of his/her genes to his/her offspring.
5. Sexual reproduction, and the passing of genes, happens only in animals – not plants.
6. The environment cannot change your genes.
7. A gene is either dominant or recessive.
8. A dominant trait is most likely to be found in a population.
9. A trait can be controlled by many genes.
10. Traits that are linked to male/female sex are found on the X chromosome.

I. How are traits passed from parent to offspring?

A. Traits

1. **Traits** are physical or physiological characteristics of an organism. Ex. height or blood type
2. The term **phenotype** is used to describe the physical expression of the trait. Ex. short/tall or Type A/Type B

B. Chemical basis of traits

How are the following terms related?
Gene, DNA, Chromosome

1. DNA is the molecule that contains the information to make proteins, which control our traits.
2. A section of DNA that is used to make a protein is called a gene. There are many genes (hundreds) on a single chromosome.
3. Eukaryotic organism's chromosomes exist in pairs. One is inherited from the sperm and one is inherited from the

egg. Each chromosome, in a pair, contains genes for the same traits. This is why we call them **homologous pairs**.

4. Although the genes on homologous chromosomes may code for the same trait, slight differences in the DNA sequences may lead to different forms of the protein. This creates slightly different versions of the same trait. Each version is called an **allele**.
   Ex. Blue and brown are two alleles of the eye color trait.
5. **Genotype** is the term used to describe the combination of alleles present in an organism's chromosomes. An allele is usually represented by a single letter. Thus, a genotype is usually represented by two letters.
   a. If an individual inherits identical copies from each parent the individual is considered **homozygous** (pure breeding). Ex. AA, aa
   b. If an individual inherits a different copy from each parent the individual is considered **heterozygous** (**hybrid**). Ex. Aa

Draw a homologous pair of chromosomes showing a different allele for eye color on each:

WORD HELP:

Pheno - _____

Geno - _____

Homo - _____

Hetero- _____

Check Yourself!

1. Give an example (not in the notes) of a human trait.
2. What is a phenotype?
3. From where did you get each of the chromosomes in the homologous pair?
4. What is an allele?
5. What is a genotype?

II. How was the path of inheritance discovered in a garden in Austria?

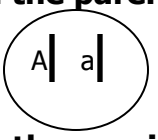
A. Gregor Mendel – The father of genetics – Using pea plants, Mendel proved experimentally the link between meiosis, genes, and inheritance (long before we knew about DNA!). He developed 3 basic conclusions:

1. The principle of **dominance**

Certain alleles (forms of a trait) can hide/mask other alleles. These alleles are called **dominant** alleles and are represented by a capital letter (A). The alleles that may be hidden are called **recessive** alleles and are represented by the lower case of the same letter (a). Thus, **homozygous dominant** is AA and will express the dominant phenotype. **Heterozygous** individuals are Aa and will also express the dominant phenotype. Only **homozygous recessive** (aa) individuals will express the recessive phenotype.

Draw a picture of a dominant and recessive trait. Write the possible genotypes under each:

Based on the parent cell:



What are the possible gametes (after segregation in meiosis)?

2. The principle of **segregation**

Alleles are <u>not</u> passed in pairs from one parent to an offspring. Each parent only donates <u>half</u> of each offspring's genotype (typically one allele per trait). This is because during meiosis only one of each homologous pair of chromosomes is passed to the gamete (sperm or egg).

Mendel's Three Laws:

1. D_____

2. S_____

3. I_____
A_____

3. The principle of **independent assortment**

The way one pair of chromosomes is separated during meiosis does not affect the way the next pair separates. A gene for one trait is only passed in connection with a gene for a different trait if the two genes are on the same chromosome. Genes on separate chromosomes are passed independently of each other.

Check Yourself!

1. Name Mendel's three principles of heredity:

2. What cell process allows the principle of segregation to take place?
3. When would a gene for one trait be passed with a gene for a different trait?

III. Does the environment affect the traits of organisms?

A. Nature vs. Nurture

Nature = _____

Nurture = _____

1. The environment does influence the expression of genes by chemically interacting with DNA or the cell, or by limiting available resources the organism requires to express the gene.
   Ex. The gene for the dark pigment (protein) for coat color in Siamese cats is activated by colder temperatures.

Watch It!

2. Environmental hazards can create genetic mutations, turning off or altering the expression of a gene. These hazards are called **mutagens**.
   Ex. Many environmental toxins mimic human hormones such as estrogen and therefore inhibit the production of that hormone by the cells.

B. Identical twins are often used to study the effects of the environment on gene expression. This is because identical twins have identical genes but are often exposed to different environments.

C. There is a cause-and-effect relationship between environmental factors and expression of a particular genetic trait:
   1. Lung/mouth cancer is linked to tobacco use. All tobacco products contain toxins and carcinogens. Carcinogens can change the DNA, causing uncontrolled division (cancer).

For each EFFECT, list the probable CAUSE(S):

1. Lung cancer - _____

2. Skin cancer - _____
_____

3. Diabetes - _____
_____

4. Heart disease - _____
_____

2. Skin cancer, sun exposure, vitamin D production, and folic acid share a complex relationship.
   a. Skin cancer is directly linked to sun exposure. UV rays mutate the DNA, causing cancer.
   b. When absorbed by the skin, sunlight also destroys folate (folic acid). Folic acid is key to DNA repair of mutations (like those caused by the sun). Folic acid deficiency is a contributor to skin cancer risks. Folic acid can be supplemented with food or vitamins.
   c. However, sun exposure is also one of the ways our body can gain vitamin D, a vitamin that helps protect us from heart disease among other health benefits. When the sun's UV-B rays hit the sun, it causes a chemical reaction that produces vitamin D. You only need about 10 minutes of exposure a day, at most, and can also supplement with food and vitamin pills.
3. Diabetes (especially Type 2 Diabetes) is linked to diet/exercise with genetic interaction. It is possible to delay or prevent type 2 diabetes by exercising and losing weight, even if there is a strong family history.
4. Heart disease is also linked to diet/exercise with genetic interaction. Different genes or gene combinations respond differently to changes in diet, health choices such as smoking, and exercise. So far, 40 or more genes have been identified that are linked to cardiovascular health.

Check Yourself!
1. Are genes "nature" or "nurture"?

2. How can the environment affect genes?

IV. How can I predict the appearance of offspring based on the traits of the parents?

A. Two kinds of inheritance

1. **Mendelian** inheritance includes any trait which has only a pair of contrasting alleles and one of the alleles is dominant to the other allele. These traits will follow Mendel's principles of heredity.
2. **Non-Mendelian** inheritance includes traits which may share dominance, be linked with a second trait (such as sex), rely on multiple genes, or have multiple forms (alleles) which may be inherited. These traits do not follow all of Mendel's principles of inheritance.

B. Probability and Inheritance

1. Punnett developed a graphical method to predict the results of a cross between two parent organisms. These are called **Punnett squares**. A Punnett square shows all of the possible outcomes each time gametes from the two parents combine.
2. Steps to solving a Punnett square:
   a. Assign each allele (form of the trait) a letter.

      Problem: Tongue rolling is dominant to non-rolling.

      Step a: Tongue rolling – R ; Non-rolling – r

   b. Determine the genotype of each parent based on the information in the problem.

      Problem: Cross two heterozygous individuals.

      Step b: Parent 1 – Rr ; Parent 2 – Rr

c. Set up the Punnett square by putting one parent's genotype across the top and the other down the side of the square. These represent possible gametes.

Step c:

	R	r
R		
r		

d. Complete the Punnett square by recording the letter on top of the column and on the side of the row. Always put the capital letter first.

e. Use the laws of probability and the Punnett square to answer any question posed in the problem.

Problem 1: What is the genotype ratio?

Answer: RR, Rr, rr

1 : 2 : 1

Problem 2: What is the phenotype ratio?

Answer: Tongue rolling , Non-rolling

3 : 1

Problem 3: What is the chance the couple will have a non-rolling child?

Answer: 1 / 4 or 25%

Genotype Ratio follows the format:

_____ : _____: _____

Phenotype Ratio follows the format:

_____ : _____

3. Punnett squares can be used to solve crosses involving only one trait (called a **monohybrid** cross) or crosses involving two traits (called a dihybrid cross). The monohybrid cross requires four squares to represent all possible gamete combinations. The dihybrid cross requires sixteen squares to represent all possible gamete combinations.

V. What are the different patterns of inheritance?

A. Mendelian dominance – dominant alleles mask rescessive alleles

Problem: Tall pea plant height is dominant to short pea plant height. Cross a pure breeding tall pea plant with a pure breeding short pea plant. Give the genotypic and phenotypic ratio.

a. Tall – H , short - h

b. Parent 1 – HH , Parent 2 – hh

c/d.

	H	H
h	Hh	Hh
h	Hh	Hh

e. Genotypic ratio: HH , Hh, hh

0 : 4 : 0

Phenotypic ratio: tall , short

4 : 0

B. Non-mendelian – 5 possible paths of inheritance

1. **Codominance** – Both alleles are equally dominant and so both are equally expressed. To represent the equal dominance each allele is assigned a different capital letter.

WORD HELP!

Co = _____

Problem: Black feathers and white feathers are codominant in chickens. Cross a chicken with black and white feathers and a chicken with only black feathers. What is the chance they will have a chick with only white feathers?

a. Black Feathers – B, White Feathers – W

b. Parent 1 (black and white) – BW, Parent 2 – BB

c/d

	B	W
B	BB	BW
B	BB	BW

e. 0% chance of chick with white feathers

2. **Incomplete dominance** – Neither allele is sufficiently dominant to mask the other allele. When both alleles are present in an individual's genotype (heterozygous) an entirely different, blended phenotype appears. To represent the incomplete dominance both share the same capital letter, but one is assigned a "prime" symbol.

Problem: In four o'clock flowers red petals and white petals are incompletely dominant. Cross a red flower and a white flower. What is the resulting phenotype of all offspring?

a. Red – R, White – R'

b. Parent 1 (Red) – RR, Parent 2 – R'R'

c/d

	R	R
R'	RR'	RR'
R'	RR'	RR'

e. All offspring are pink.

3. **Multiple Alleles** – More than two alleles exist within the population for the given trait. However, each individual may only inherit two of the possible alleles. To represent the multiple alleles a base letter is used for each allele and the allele is represented by a unique superscript letter.

Problem: Blood type in humans is determined by multiple alleles: I^A, I^B, i. In addition, I^A and I^B are codominant, while i is recessive to both. Below is a chart representing all the possible genotypes and resulting phenotypes.

Blood Type (Phenotype)	Possible Genotypes
Type A	I^AI^A or I^Ai
Type B	I^BI^B or I^Bi
Type AB	I^AI^B
Type O	ii

Draw a blood cell for each type:

A –

B –

O –

Alleles for Blood Type:

Allele for A = I^A

Allele for B = _____

Allele for O = _____

Cross a heterozygous Type A female with a Type O male. What are all the possible blood types of the offspring?

a/b Parent 1 – I^Ai, Parent 2 – ii

c/d

	I^A	i
i	I^Ai	ii
i	I^Ai	ii

e. Type A and Type O are the possible blood types.

4. **Sex-linked** – One of the pairs of chromosomes in an organism determines the sex. This pair is called the sex chromosomes. In humans the two types of sex chromosomes are represented by an X and a Y. Inheriting two X chromosomes makes a female; inheriting an X and a Y chromosome makes a male. The genes located on a sex chromosome (almost always the X chromosome) are called sex-linked genes. Thus, females inherit two alleles for the trait while males only inherit one allele for the trait.

What makes sex-linked genes DIFFERENT from other genes?

Problem: Colorblindness is a recessive sex-linked trait. A colorblind man has a child with a woman who is a carrier (heterozygous) for colorblindness. What is the chance they will have a colorblind son?

a. "Normal" vision – X^B, Colorblind - X^b

b. Parent 1 – X^bY, Parent 2 - X^BX^b

c/d

	X^B	X^b
X^b	X^BX^b	X^bX^b
Y	X^BY	X^bY

e. There is a 25% chance they will have a colorblind son

The SIX paths of inheritance:

1. M_____ (A, a)

2. C_____ (A, B)

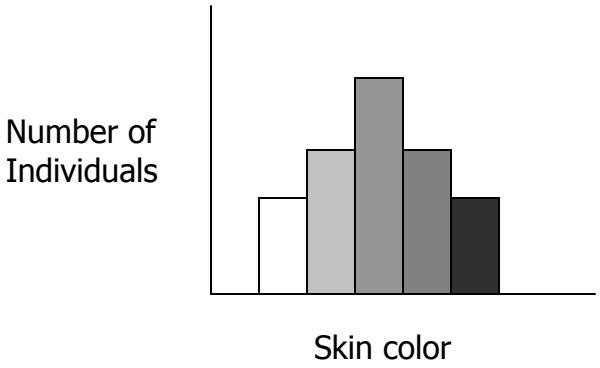
3. I_____
D_____ (A, A')

4. M_____
A_____ (I^A, I^B, i)

5. S_____ - l_____ (X^A, X^a)

6. P_____ (AaBbCc)

5. **Polygenic inheritance** – Many traits actually depend on several genes. The interaction of the many genes within one individual creates a range of phenotypes. For example height, skin color and the size of your foot depend on the total number of dominant alleles inherited for these traits. This means someone with four dominant alleles will have a slightly bigger foot than someone with three dominant alleles. This results in a characteristic graphical pattern seen below:



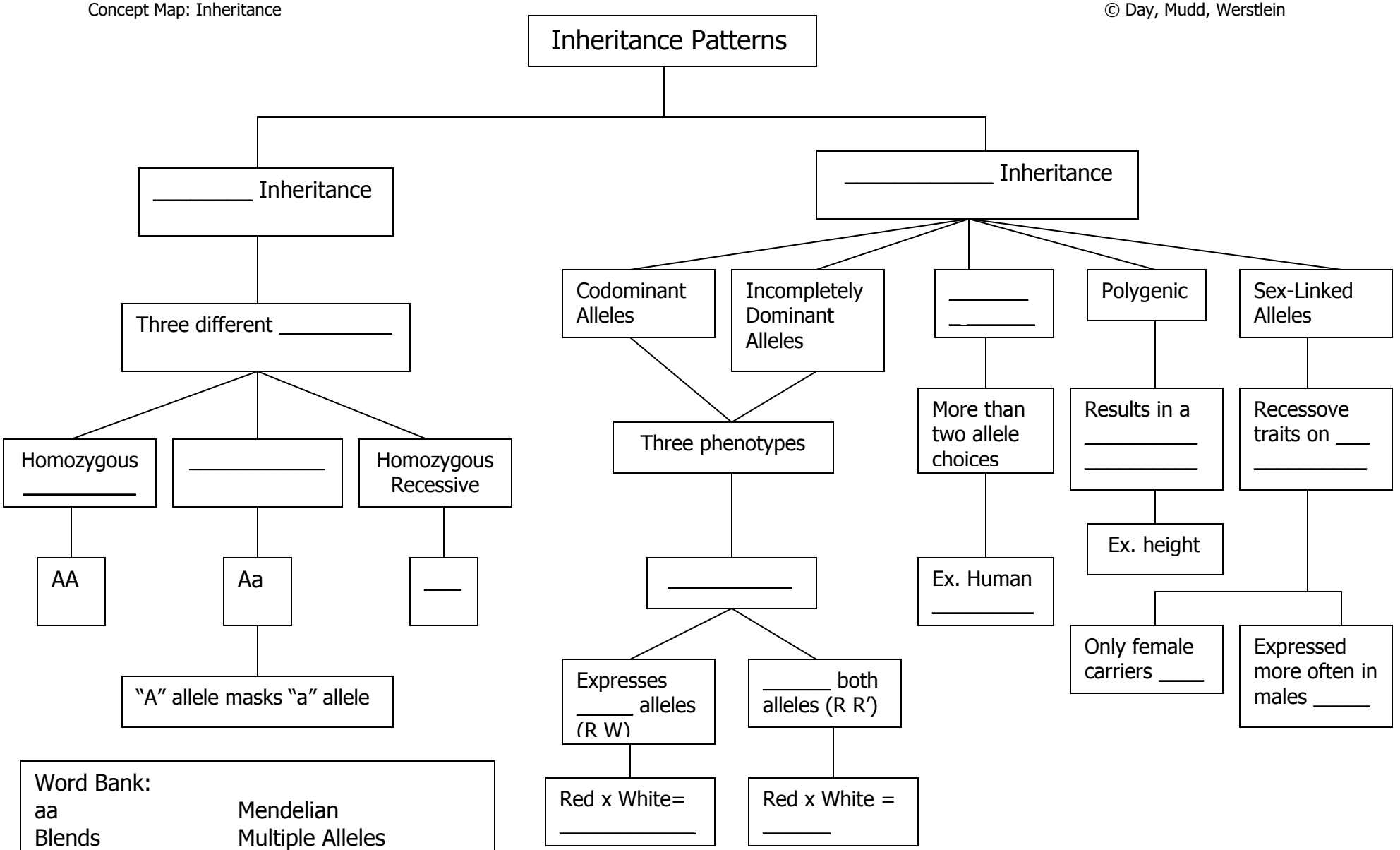
Check Yourself!

1. Name the five paths of non-Mendelian inheritance.

2. Which pattern of inheritance results in a third, blended phenotype in heterozygous individuals?

3. What two patterns of inheritance does human blood type follow?
4. Where are sex-linked traits located?

5. Name three traits that follow polygenic inheritance.



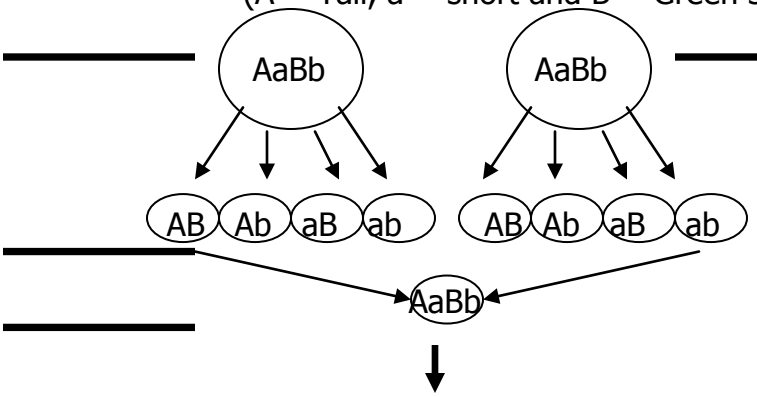
Word Bank:

aa	Mendelian
Blends	Multiple Alleles
Blood Type	Non-mendelian
Both	Pink
Dominant	Range of phenotypes
Genotypes	Red and White
Heterozygous	X^BX^b
Heterozygous	X^bY

Unit 3 / Module 8

Problem-Solving Set

1. On the diagram, **label** the parent cells (there are two!), gametes, and zygote using the bold lines. Then identify which of the Mendel's principles can best explain the events of each stage:
(A = Tall, a = short and B = Green seed, b = yellow seed)



Mendel's Principles:

a._____

b. _____

2. Use the data collected by a scientist studying identical twins who were separated at birth to answer the following questions.

Characteristics:	**Twin A – Geoff**	**Twin B - Bryan**
Height	6 feet, 0 inches	6 feet, 1 inch
Weight	180 pounds	200 pounds
Favorite Food	Grilled salmon	Steak
Favorite Movie	Rudy	A Beautiful Mind
Medical Conditions	Red-green colorblindness	Red-green colorblindness
IQ Test Score	110	115

a. Which one of the six characteristics, based on the data, is <u>most likely</u> **entirely** genetic? _____
b. Which one of the six characteristics, based on the data, is <u>most likely</u> **entirely** environmental? _____
c. List the four characteristics, based on the data, <u>most likely</u> due to a combination of genes and environment? _____
_____
d. Height has been proven to have a genetic basis, yet the two twins are not identical heights. What reasons may explain differences in the height of the twins? _____
_____
e. The scientist gathered information about the adoptive parents (non-biological). Would this information, when compared to the twins, help identify **genetic** or **environmental** factors? _____

3. For each of the following Mendelian genetic problems, construct a Punnett square based on the problem to illustrate the cross and then answer the question(s):
    a. In vampires, long fangs are dominant to short fangs. Cross two heterozygous long-fanged vampires. What will be the genotypic and phenotypic ratios of this cross?

Genotype ratio: _____

Phenotype ratio: _____

    b. In werewolves, the ability to shift when the moon is NOT full is recessive. Grace (who could shift at any time) married Sam (who could not but whose mother could). Would they be able to have a child with this ability?

Would they be able to have child who could shift at any time? _____

4. For each of the following codominance genetic problems, construct a Punnett square based on the problem to illustrate the cross and then answer the question(s):
    a. In Totoro populations, gray fur is codominant to white fur. O Totoro has gray and white fur. Chibia Totoro has only white fur. If O and Chibia have children, what is the chance that child will have only white fur?

Chance of a child with only white fur? _____

    b. In the Pikachu population, a black ear color is codominant to yellow ear color. Kuro Pikachu, who has all-black ears, marries Kiiro Pikachu, who has all yellow ears. What is the probability they will have a child with yellow-and-black ears ?

Probability of a child with yellow-and-black ears? _____

5. For each of the following <u>incomplete dominance</u> genetic problems, construct a Punnett square based on the problem to illustrate the cross and then answer the question(s):

   a. In Pac-Man ghosts, the heterozygote is orange. A homozygous red Blinky ghost is crossed with the blue Inky ghost. What is the phenotype of the offspring?

Phenotype of offspring?
_____

   b. In Frogger frogs, eye color is incompletely dominant. The possible genotypes are RR (red), R'R' (blue), and RR' (purple). Two purple-eyed froggers make it across the road, get married, and have children. What are the possible genotypes of the offspring?

Possible genotypes?
_____

6. For each of the following <u>multiple allelic</u> AND <u>co-dominant</u> genetic problems about blood types, construct a Punnett square based on the problem to illustrate the cross and then answer the question(s):

   a. Katniss has Type AB blood and Peeta has Type O blood. Could this couple have a Type B child?

Could they have a type B child?_____

   b. A mix-up has occurred at the Atlanta Braves hospital! Below are the blood types of the parents and the switched babies. Match the correct baby with the parents.

<u>Correct Baby</u>	<u>Parents</u>	<u>Babies</u>
_____	Mr. McCann (A) and Mrs. McCann (A)	Baby A (AB)
_____	Mr. Jones (O) and Mrs. Jones (AB)	Baby B (O)
_____	Mr. Uggla (B) and Mrs. Uggla (A)	Baby C (A)

7. For each of the following sex-linked genetic problems, construct a Punnett square based on the problem to illustrate the cross and then answer the question(s):
    a. Colorblindness is sex-linked and recessive. What is the chance that a couple will have a colorblind son if the mom is a carrier and the dad has normal vision?

Chance of a colorblind son? _____

    b. Black and orange coat color in cats is BOTH codominant and sex-linked. A calico cat is a female who is both orange and black. A breeder has a black male cat and wants to sell calico kittens. What color female cat should the breeder choose to guarantee female calico kittens?

What color female cat should the breeder choose?
_____

8. For each of the following pairs of terms, explain how they are different from each other.
    a. Incomplete dominance and codominance
    _____
    _____
    b. Multiple alleles and polygenic inheritance
    _____
    _____
    c. Medelian and sex-linked inheritance
    _____
    _____

9. For each of the following descriptions of the results of a genetic cross, write the path of inheritance that is most likely:
    a. Red Parent x White Parent = Pink Offspring
    _____
    b. Red Parent x White Parent = Red and White Offspring
    _____
    c. 80% of individuals with the trait are male.
    _____
    d. Range of phenotypes (graphed trait looks like a bell curve)
    _____

Unit 3: DNA and Genetics

Module 9: Human Genetics

NC Essential Standard:
- 3.2.3 Explain how the environment can influence expression of genetic traits
- 3.3.3 Evaluate ethical issues surrounding the use of DNA technology (including the HGP)

STOP!

True or False …What do you think?

1. If a person "shows" a trait, that trait is dominant.
2. If a person does NOT "show" a trait, the person does not have that gene .
3. If a father has a sex-linked disease, so will any son of that father.
4. Down's Syndrome occurs when you have an extra chromosome of any type.
5. You can see a chromosomal defect when looking at a person's chromosomes.
6. Genetic disorders are not affected by the environment (such as what you eat).
7. If a person has a single gene defect, that can be seen with a picture of the entire chromosome.
8. All genetic disorders are caused by recessive genes.
9. The mother determines the sex of the child.
10. Having extra chromosomes means a human will have stronger traits.

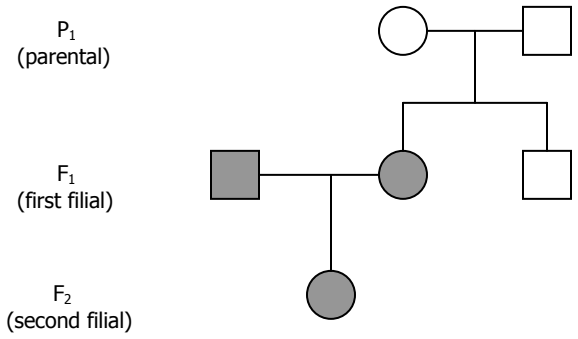
I. How can you study human heredity?

1. Population sampling determines how often a trait appears in a small, randomly selected group. This percentage is then applied to the entire population to predict the number of individuals with that trait.
2. Pedigrees graphically record the inheritance of a single trait over several generations. Typically, the occurrence of the trait is determined based on family/historical documents, interviews, photographs, and medical records.
   a. Specific shapes are used to represent individuals in a pedigree:

Individual	**With Trait**	**Without Trait**
Female		
Male		

Draw a pedigree that shows a mom and dad that have two girls, one boy. The boy is married. Indicate that all of the males have the trait.

b. Connecting lines are used to indicate relationships among individuals within the family.



c. Pedigrees demonstrate the pattern of inheritance (dominant/recessive, sex-linked) of the single trait.

d. Pedigrees can be interpreted to determine the presence of carriers (individuals who do not express the trait but may pass the gene on to offspring). Example: The two parents (P_1 generation) must have been carriers (Bb) for a recessive trait. Neither showed the trait, but they had a child with the trait (bb).

Signs a pedigree shows a trait that is…

Recessive –

Sex-linked –

Check Yourself!

1. In a pedigree, what shape represents a male?
2. What are lines used to indicate, in a pedigree?
3. What do pedigrees tell us about the inheritance of a trait in a family?

II. How do you get a genetic disease?

A. **Gene diso**rders are inherited as a single gene on a chromosome. Most gene disorders are recessive. Thus, in order to express the disorder, the individual must be homozygous recessive. Science hypothesizes that gene disorders arose from mutations that disabled specific proteins, or increase production harmfully.

What does "autosomal" mean?

1. **Autosomal genetic diseases** occur when the gene defect is on one of the first 22 pairs of chromosomes (called the autosomal chromosomes).
   a. **Huntington's disease** is inherited as an autosomal dominant gene. Huntington's disease breaks down certain areas of the brain. In addition to being dominant, Huntington's is also unique because symptoms begin appearing in the person's late forties.
   b. **Sickle-cell anemia** is inherited as a codominant autosomal gene. Sickle-cell anemia leads to misshapen red blood cells which lead to poor circulation and pain. Sickle cell is unique because heterozygous individuals are not afflicted by sickle cell AND are able to resist malaria (which is handy in certain areas of the world). Currently, sickle cell is primarily in African populations.
   c. **Cystic fibrosis** is inherited as a recessive autosomal gene. Cystic fibrosis leads to mucus build up in lungs and digestive tract, which may be fatal. Currently, this disease is primarily in Caucasian populations.
   d. **Tay-Sach's** is inherited as a recessive autosomal gene. Tay-Sach's degenerates (breaks down) the central nervous system leading to premature death (2-4 years of age). Currently, Tay-Sach's is primarily in Jewish and Pennsylvania Dutch populations.

List genetic diseases that are…

Dominant:

Codominant:

Recessive:

Watch It!

e. **Phenylketonuria** (PKU) is inherited as recessive autosomal gene. PKU leads to the inability to break down the amino acid phenylalanine when ingested. The phenylalanine builds up in the brain and leads to decreased mental function. PKU is unique because, if detected early, it can be entirely controlled by diet. Individuals can simply not consume products containing phenylalanine (dairy, breads, proteins, etc). However, any damage done before detection is irreversible. In hospitals, children are tested at birth.

2. **Sex-linked genetic diseases** occur when the gene defect is on the last pair (23rd) of chromosomes (called the sex chromosomes). Because males inherit only a single X chromosome (they are XY) and the X carries the majority of sex-linked genes, males are MORE LIKELY to express sex-linked disorders and cannot be carriers of these traits.

Contrast "autosomal" with "sex-linked" using a T-chart or Venn below. Include specific diseases:

a. **Hemophilia** is inherited as a recessive sex-linked gene. Hemophilia leads to low production of blood clotting factors which leads to excessive bruising and bleeding.

b. **Red-green color blindness** in inherited as a recessive sex-linked gene. People with red-green color blindness are unable to distinguish red from green colors (both colors often appear a muddy brown).

B. **Chromosomal disorders** are inherited due to problems with an entire chromosome (which may contain hundreds of genes!) Thus, an individual with even one chromosomal defect will most likely express the disorder. Science hypothesizes that chromosomal disorders arise from mistakes in meiosis during gamete formation. For example, a sperm cell may receive 22 instead of 23

WORD HELP!

"non" - _____

"disjunction" is the state of being disconnected

chromosomes. This incorrect distribution of chromosomes is called **nondisjunction**. Nondisjunction may lead to **aneuploidy** - an incorrect number of chromosomes in a fertilized zygote.

1. An **autosomal chromosome aneuoploidy** refers to having one extra autosome. For example, **Trisomy 21** (three #21 chromosomes), leads to **Down's Syndrome**. Characteristics of Down's Syndrome include some level of mental retardation, heart defects, flat facial features, and an enlarged tongue.
2. A **sex chromosome aneuploidy** refers to having one extra or one too few sex chromosomes.
   a. **Turner's Syndrome** is the result of inheriting a single X chromosome (genotype XO). These individuals are female but lack secondary sex characteristics, are infertile, and have some lack of mental function.
   b. **Klinefelter's Syndrome** is the result of inheriting an extra X chromosome in males (genotype XXY). These individuals are male but lack secondary sex characteristics, are infertile, and have some lack of mental function.

WORD HELP!

"a" - _____

"neu" - _____

"ploid" means the number of chromosomes present in a cell.

Check Yourself!

1. What is the difference between a gene disorder and a chromosomal disorder?

2. What is the difference between an autosomal disorder and a sex-linked disorder?

3. Why is hemophilia considered a sex-linked disease?

4. What is an aneuploidy?

III. Can we tell if a baby has a genetic disease?

A. A **genetic counselor** can help prospective parents determine the likelihood of passing some harmful genetic traits to their offspring and may suggest further testing procedures. Counselors may also interpret diagnostic procedures done by the doctor for parents.

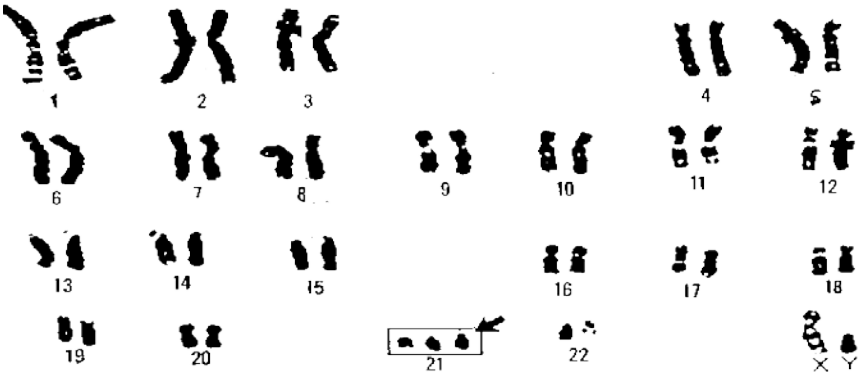
1. **Sonograms** / **ultrasounds** use sound waves to produce an image of the developing fetus. This may be used to detect physical abnormalities (such as cleft palate).
2. Blood tests of the pregnant mother may screen for certain proteins to assess the risk level of certain genetic disorders
3. **Amniocentesis** removes amniotic fluid containing fetal cells. The cells are then cultured until mitosis occurs and the chromosomes are visible. A **karyotype** (a picture of the chromosomes) is made using the visible chromosomes. The karyotype allows doctors to detect chromosomal abnormalities and the sex of the child but does NOT detect gene abnormalities because the gene sequence is molecular, and not visible.

What genetic disorder is present in this karyotype?

How do you know?

What is the sex of this person?

How do you know?



4. **Chorionic villi sampling** (CVS) removes actual tissue from the placenta (which is composed on embryonic cells) in order to create a karyotype. This may be done earlier in the pregnancy, but is far more invasive and thus riskier.

B. The **Human Genome Project** has allowed science to develop certain genetic markers. A genetic marker detects the presence of certain gene variations on the chromosomes. These genes may either be a direct cause of a disorder or may simply indicate a predisposition for a trait. Doctors or genetic counselors may use genetic markers to screen parents and determine if the parents may be carriers for genetic disorders.

Check Yourself!

1. Name 4 pre-natal tests that may detect genetic disorders.

2. What is a karyotype?

3. Why aren't individual genes visible on a karyotype?

IV. Can you prevent and/or treat genetic disorders?

A. Currently, there is no "cure" for genetic disorders because the disorder stems from your DNA. However, the symptoms of genetic disorders can be treated and experimental trials for replacing defective genes are underway. **Gene therapies** are being developed using information from the Human Genome Project. These therapies seek to use engineered cell invaders (such as a virus) in order to actually replace the defective gene in target cells with a functioning gene.

B. **Environmental factors** may play a large role in the expression or progression of certain genetic problems. Environmental factors that interact with genes can be controlled to help prevent the eventual expression of known genetic predispositions.

1. Appropriate diet can stop the progression of PKU. Diet may also limit the risk for genetic predispositions such as heart disease, alcoholism, and certain cancers.
2. Environmental toxins such as UV radiation and tobacco products can directly change our genes. Harmful behaviors (such as smoking) and positive behaviors (such as using sun screen) increase or reduce the likelihood of genetic mutations from these toxins. The mutations may lead to cancers if protective genes are disrupted.

What aspect of PKU is …

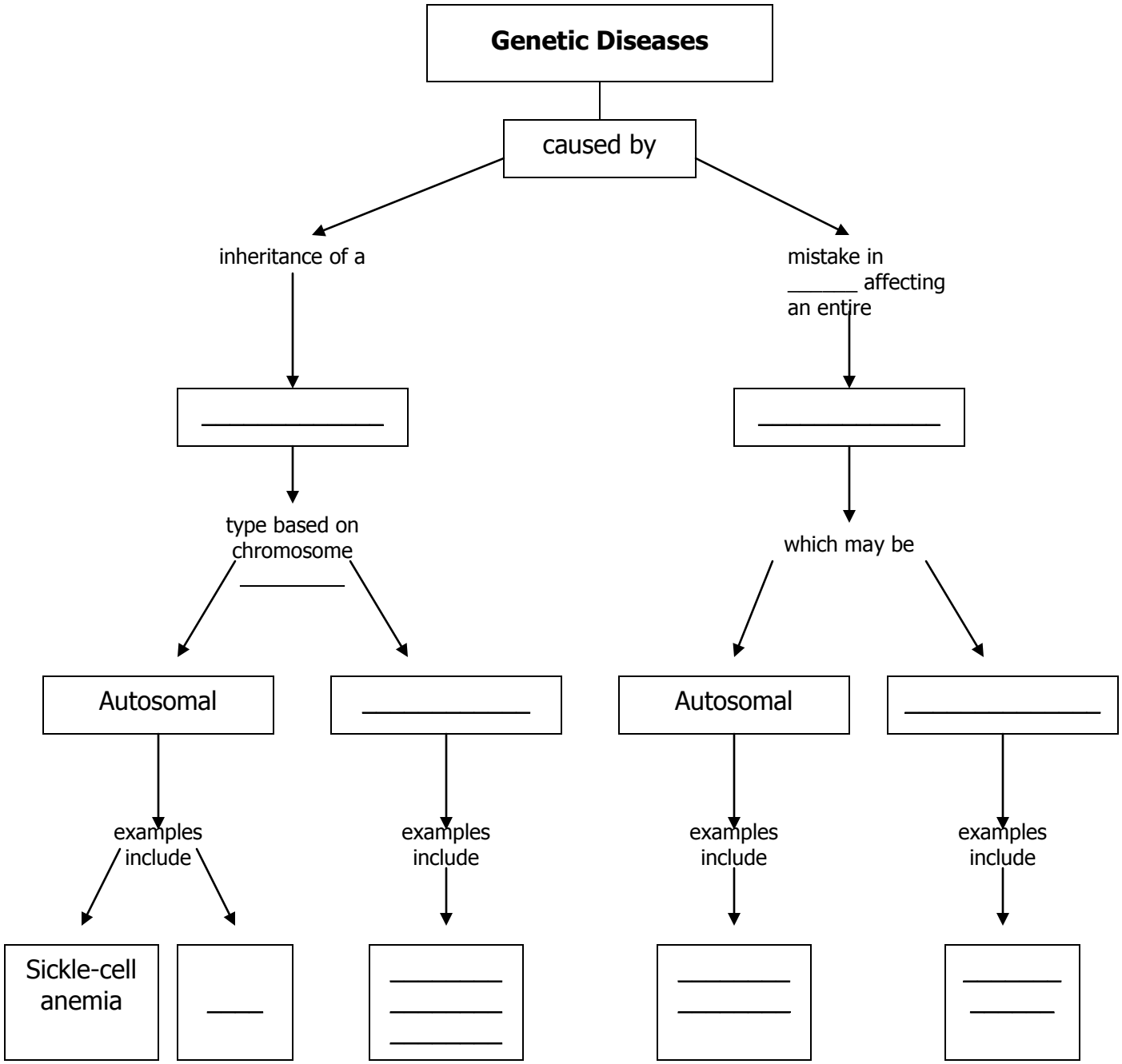
Genetic (Nature)?

Environmental (Nurture)?

Check Yourself!

1. What is gene therapy?

2. Identify two environmental toxins that may affect genes.

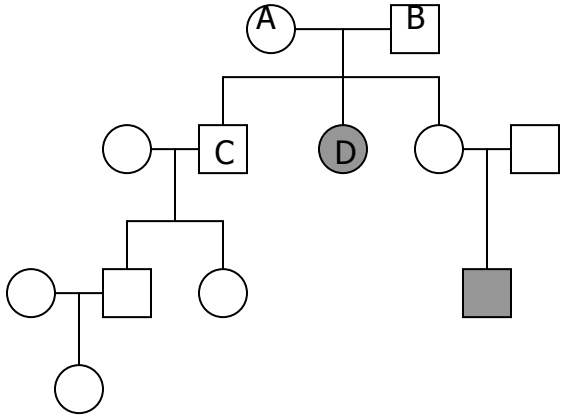


Word Bank:	
Chromosome	PKU
Defective gene	Sex Chromosome
Down's syndrome	Sex-linked
Location	Turner's (XO)
Meiosis	

Unit 3 / Module 9

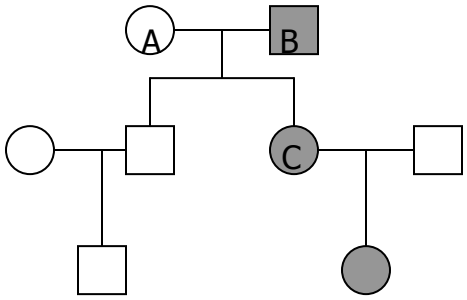
Problem-Solving Set

1. The pedigree below shows the inheritance of cystic fibrosis in a family.



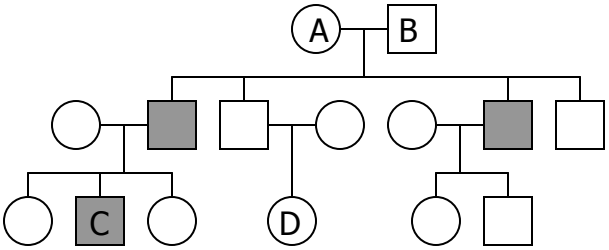
   a. How many generations are represented in the pedigree? _____
   b. What is the pattern of inheritance for cystic fibrosis? _____
   c. What is the genotype for individuals A and B? _____
   d. Could individual C be a carrier? _____
   e. What is the genotype for individual D? _____

2. The pedigree below shows the inheritance of Huntington's disease.



   a. How many males are in the pedigree? _____
      How many females? _____
   b. What is the pattern of inheritance for Huntington's disease?
      _____
   c. What is the genotype for individual A? _____
   d. What are the possible genotypes for individual B? ____ or ____
   e. What is the genotype for individual C? _____

3. The pedigree below shows the inheritance of hemophilia.



   a. How many children do the 1st generation parents have? _____
   b. What is the pattern of inheritance for hemophilia? _____
   c. What is the genotype for individual A? _____
   d. What is the genotype for individual B? _____
   e. What is the genotype for individual C? _____
   f. What is the genotype of individual D? _____

4. You are the head geneticist at Bulldog Memorial Hospital and have been presented with several cases to diagnose. Read each of the following patient descriptions, then indicate which genetic disorder the patient is most likely suffering from.

Age: 11 months Racial background: Jewish Development appeared to be progressing normally until the last month. The infant exhibits jerky movements, and seems to be losing the ability to smile and lift his head. Diagnosis: _____	Age: 42 Racial background: Caucasian Patient has recently begun to experience slurred speech. Body movements are becoming uncontrol-able. The patient's father experienced similar symptoms before his death at age 45. Diagnosis: _____
Age: 22 Racial background: African-American The patient frequently experiences excruciating pain, especially in the extremities. This is more pronounced after exercise or periods of stress. A recent blood test showed abnormally shaped red blood cells. Diagnosis: _____	Age: 7 Racial background: Caucasian Patient has frequent respiratory infections and often coughs up excessive amounts of mucous. She also has difficulty digesting certain types of foods. Diagnosis: _____

Age: 18 months
Racial background: Asian

Infant development appears to be progressing more slowly than normal. The patient's eyes are sloped and the tongue is quite large. A karyotype revealed an extra chromosome #21.

Diagnosis: _____

Age: 5 months
Racial background: Caucasian

Infant is unresponsive and appears to be developmentally delayed. The mother denied a blood test at birth and has been feeding the child a milk-based formula.

Diagnosis: _____

Age: 18
Racial background: Caucasian

Patient has underdeveloped secondary sex characteristics and also exhibits slight mental retardation. A karyotype revealed that she lacks one sex chromosome.

Diagnosis: _____

Age: 19
Racial background: Caucasian

Patient lacks muscular development and exhibits some degree of female secondary sex characteristics. He is tall and lanky, and is slightly developmentally delayed.

Diagnosis: _____

Age: 6
Racial background: African American

Patient bruises easily and often bleeds profusely from small wounds. Other male members of his family have also experienced these problems.

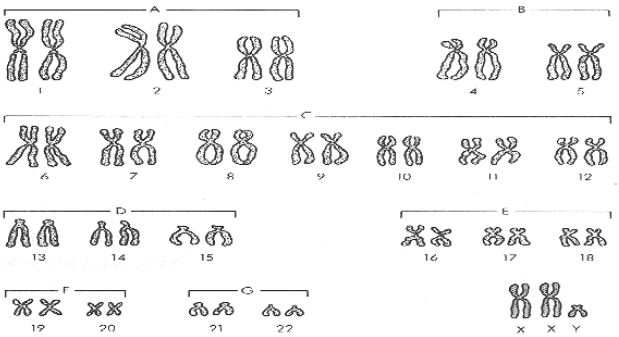
Diagnosis: _____

Age: 4
Racial background: Hispanic

Patient's mother is concerned that his is unable to learn his colors in kindergarten. He is unable to perform simple tasks such as matching his socks when dressing.

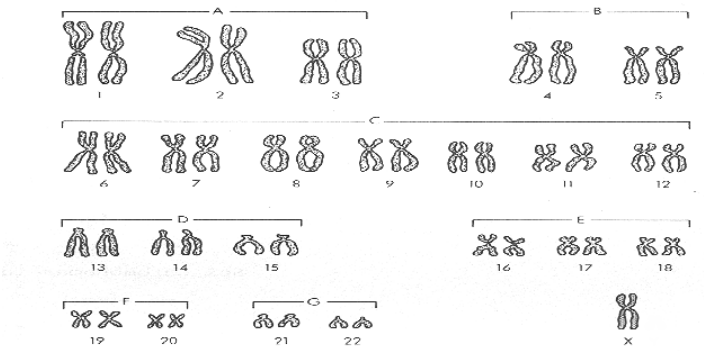
Diagnosis: _____

5. Use the karyotypes below to diagnose the chromosomal disorder:



Diagnosis:
_____
(circle the abnormality on the karyotype)

Male or Female?

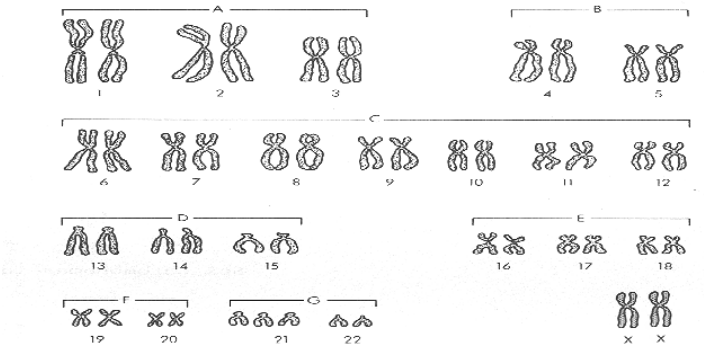


Diagnosis:

_____

(circle the abnormality on the karyotype)

Male or Female?



Diagnosis:

_____

(circle the abnormality on the karyotype)

Male or Female?

5. Explain why gene disorders such as sickle-cell anemia and PKU can **not** be diagnosed with a karyotype.

   _____

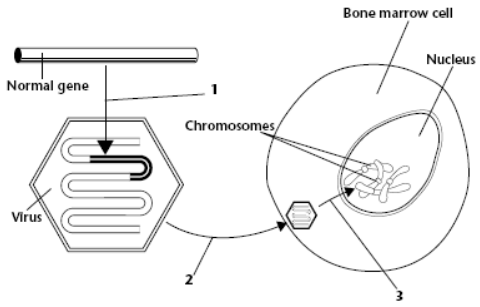
   _____

   _____

6. In the near future, it may be possible for physicians to test for genetic predisposition to problems such as alcoholism or breast cancer. Identify one "pro" and one "con" to this technology.

   Pro: _____

   Con: _____

7. 

The diagram shows how a virus may be used to insert a normal gene into a cell during gene therapy. Put the steps in the correct sequence:

_____ Virus infects human cell

_____ Normal gene is inserted into viral DNA

_____ Virus delivers its DNA to human cell

Image credits:
http://www.emc.maricopa.edu/faculty/farabee/biobk/BioBookhumgen.html
http://www.phsuccessnet.com

Unit 4: Evolution and Classification

Module 10: Evolution

NC Essential Standard:

- 3.4 Explain the theory of natural selection as a mechanism for how species change over time.

STOP!

True or False …What do you think?

1. The environmental conditions of earth have changed since life began and are continuing to change today.
2. Evolution happens when individuals "get used to" a new situation.
3. Individuals can develop new traits because they need them for survival.
4. Except for differences between males and females and young and old, all members of a population look and act the same.
5. Evolution occurs when favorable, inherited traits lead to successful reproduction in some individuals.
6. Species that have no obvious, physical similarities have no similarities at all.
7. Humans share a common ancestor with other species.
8. Humans evolved from other primates such as apes.

I. How could life have begun on a lifeless Earth?

A. Abiogenesis / Spontaneous Generation

Abiogenesis =

1. **Abiogenesis** is the idea that life came from non-living material. This idea is sometimes called **spontaneous generation**.
2. The environment of the early Earth may have provided a unique set of conditions that allowed abiogenesis to occur. Researchers now believe that the early atmosphere may have been similar to the vapors given off by modern volcanoes: carbon monoxide, carbon dioxide, hydrogen sulfide, and nitrogen (note the absence of free atmospheric oxygen).

Gases then =

Gases now =

What was found in the "primordial soup"?

a. Oparin developed a theory to explain the development of life on earth. His theory hypothesized that due to the chemicals in the atmosphere, the lack of free oxygen, and intense energy from lightening and volcanoes, simple organic molecules could form from inorganic compounds. At this time in earth's history the earth was covered by water. Therefore, this essential first step in the development of life must have occurred in the oceans. This supports the idea that life originated as a "**primordial soup**" in the oceans.

b. Miller and Urey designed an experiment to test Oparin's "primordial soup" hypothesis. They were able to successfully mimic the proposed conditions of early earth in the laboratory. Up to 4% of the carbon was converted to amino acids (the building blocks of proteins). This experiment has been replicated numerous times.

B. Biogenesis

1. Once life was established in very simple cells, biogenesis began. **Biogenesis** is the continuation of life from other living cells. For a long time people believed that non-living material could produce living things (spontaneous generation). For example, it was a common belief that fish arose from the mud in the bottom of a river.

Abiogenesis	**Biogenesis**

a. Francesco Redi set out to disprove the theory of spontaneous generation/abiogenesis. He developed a controlled experiment to test his hypothesis that life must come from life (biogenesis).

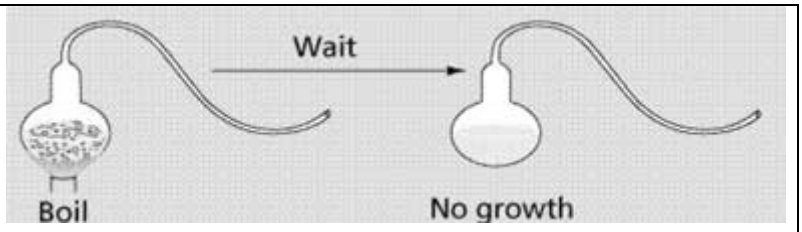
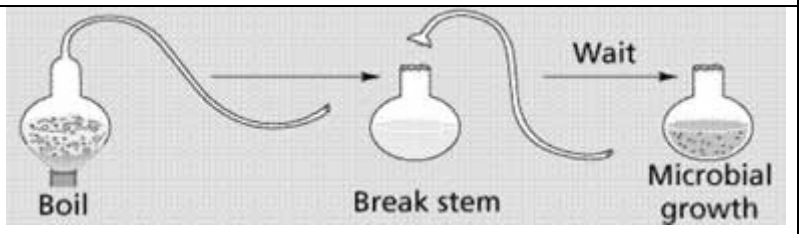
Redi's Experiment:

	Control Group	**Experimental Group**
Independent Variable	Open jars	Covered jars
Constant	Rotting meat	Rotting meat
Observations	Flies entered jars, landing on the meat	Flies were unable to enter the jar
Results	Maggots developed on meat	No maggots developed on meat
Conclusions	The maggots came from the flies, NOT the meat.	

b. After the development of the microscope and thus the discovery of microorganisms, Redi's work was called into question. Did the microscopic organisms come from a vital force in the air or did biogenesis hold true at all levels?

c. Louis Pasteur designed an experiment to disprove spontaneous generation for microorganisms.

Pasteur's Experiment:

Experimental Group	
Control Group	
Conclusion	Microorganisms came from other microorganisms carried on dust in the air, NOT the air itself.

vilenski.org/.../ historyoflife/pasteur.html

C. The evolution of cells

1. Based on the conditions proven by Miller and Urey, scientists developed the **heterotroph hypothesis** to explain the evolution of prokaryotic cells.
   a. The first cells would have been prokaryotic (no nucleus), anaerobic (does not require oxygen), and heterotrophic (must take in nutrients). Prokaryotic, heterotrophic cells are the simplest cells and therefore most likely to evolve first. The lack of free atmospheric oxygen would have required an anaerobic cell.
   b. Over time photosynthetic prokaryotic cells evolved, allowing for the release of free oxygen. This profoundly changed earth's environment and led to the development of an ozone layer.
   c. The production of oxygen led to conditions that favored the evolution of aerobic, prokaryotic cells.
2. Based on the idea of biogenesis and current research in symbiosis, Lynn Marguilis developed the **endosymbiont hypothesis** to explain the development of eukaryotic cells.
   a. A variety of prokaryotic cells existed, some autotrophs and some heterotrophs.
   b. A larger heterotrophic cell consumed the smaller cells, using some of them for food. However, the energy harnessing power of these smaller cells could also be used by the larger cells.
   c. A symbiotic relationship was formed and the smaller cells evolved into what we now know as mitochondria and chloroplasts. A nuclear envelope formed around the DNA.

The effect of photosynthetic cells:

1.

2.

3.

Watch It!

Check Yourself!

1. What is abiogenesis?

2. What were the conditions of the early atmosphere?

3. What three scientists are credited with developing and supporting the theory of these conditions on early Earth?

4. What is biogenesis?

5. What two scientists disproved spontaneous generation using controlled experiments?

6. What does the heterotroph hypothesis explain?

7. What does the endosymbiont hypothesis explain?

II. How did all of life on Earth come from a few cells?

A. Theory of Evolution

1. theory of evolution, but there were many people that contributed ideas upon which he built his own. Darwin also developed his ideas based on his travels as the ship naturalist on the H.M.S. Beagle. Of particular interest to Darwin were the animals of the Galapagos Islands.
2. In 1859, Darwin and Alfred Wallace jointly proposed that new species could develop by a process of **natural selection**. The theory can be described as a process:

Steps of Natural Selection

1.

2.

3.

4.

a. **Variation** of traits within the population leads to different phenotypes. Some variations are better suited to the current conditions of the environment.
b. **Overproduction** in populations leads to competition for limited resources (food, for example).
c. **Natural selection** favors the best suited phenotype at the time. This does not necessarily mean that those struggling die, but will be in a poorer condition.
d. The **survival** (or better success) **of the best adapted** individuals leads to higher reproductive success. The variations will be passed on to the offspring. Over time, if the environment does not change, those favorable variations will be seen more frequently in the population because nature has "selected" that trait.

3. Central to the theory of natural selection is the idea of adaptations. An **adaptation** is any heritable trait that suits an organism to its natural function in the environment (its niche). There are three basic types of adaptations:

A body-builder's large muscles would NOT be an adaptation because….

a. Examples of structural adaptations are defensive structures, camouflage, and mimicry. Typically, mimicry occurs when a harmless species (mountain king snake) resembles a harmful species (coral snake) using coloration.
b. Examples of behavioral adaptations are herding, schooling, and growling
c. Examples of physiological adaptations are enzymes, oxygen-binding of hemoglobin, and sight.

Check Yourself!

1. Who is credited with developing the theory of natural selection?

2. List the four steps in the process of natural selection.

3. What is an adaptation?

B. Mechanisms of Evolution

1. Individuals don't evolve; populations do. The population is the smallest unit of evolution because acquired traits in an individual cannot be passed on (inherited by offspring). However, different traits already present in a population can be "selected", changing the population.
2. Evolution occurs when the **gene pool** (all of the genes of a population) changes. A change in genotype may lead to a change in phenotype. Evolution acts on the phenotype.

Mutations → _____ **in** _____ **→ change in** _____

a. **Mutations** are random changes in DNA and may lead to a new phenotype. Mutations provide the raw material for evolution – diversity. For example, a mutation causing white fur in Arctic foxes may lead to better camouflage in winter.

b. The environment also plays a key role in evolution. Environmental changes are natures "**selection forces**" that act upon the phenotype ranges caused by genes. There are three basic patterns by which natural selection occurs:

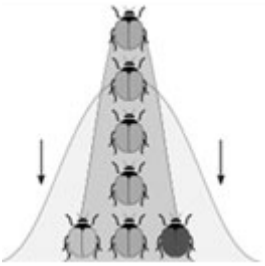
Three types of Natural Selection:

1.

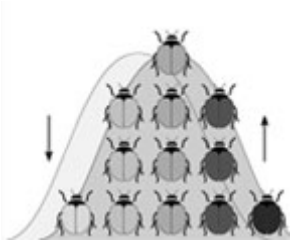
2.

3.

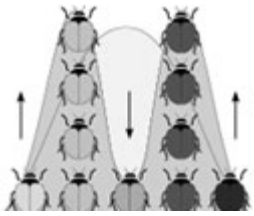
i. **Stabilizing selection** favors the "average" phenotype in a population.



ii. **Directional selection** favors ONE of the extreme ends of the "typical" distribution.



iii. **Disruptive Selection** favors BOTH of the extreme ends of the "typical" distribution.



w3.dwm.ks.edu.tw/bio/ activelearner/18/ch18c6.html

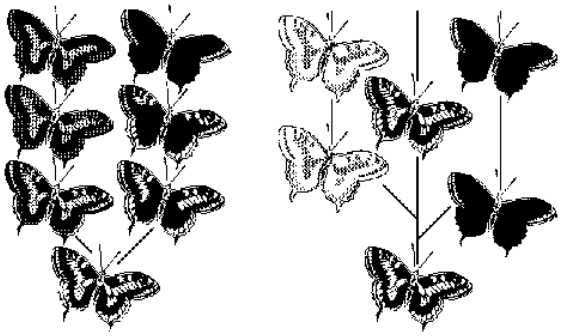
3. **Speciation** is the development of a new species. A species is defined as a group of organisms that can produce fertile offspring. Speciation occurs when a population is separated, usually due to a geographical barrier, and natural selection changes the population so much the two groups could no longer interbreed. Therefore, **geographic isolation** leads to **reproductive isolation**.

Geographic isolation is related to speciation because…

C. Timeframes of evolution differ based on the environment and the population. The fossil record provides evidence for two rates of speciation:

1. **Gradualism** describes speciation that occurs over a long period of time due to the accumulation of small changes.
2. **Punctuated equilibrium** describes speciation that occurs in rapid bursts that may be separated by 1000's of years of stability. The primary stimulus is environmental change.

Venn Diagram: (Gradualism vs. Puntuated Equilibrium)



gradualism punctuated equilibrium

abyss.uoregon.edu/.../ lectures/lec09.html

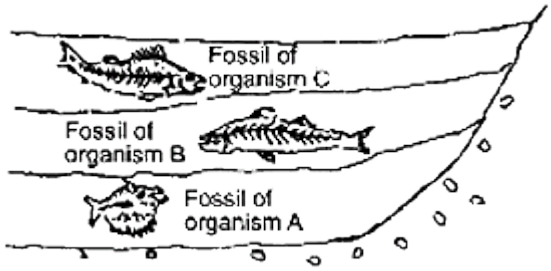
Check Yourself!

1. Why can't individuals evolve?
2. What provides the raw material for evolution?
3. What are the three types of natural selection?
4. What is speciation?
5. What condition leads to reproductive isolation?
6. Name the two time frames for speciation.

D. Evidence for Evolution

1. Fossil evidence provides an incomplete record of early life. **Fossils** can include any evidence of life, such as imprints and remains of organisms. This evidence must be interpreted to form an overall picture of how species have changed over time (evolved). By examining the fossil record, scientists have concluded that evolution happens in a simple to complex pattern and life emerged from sea to land. Fossils must be dated to help establish a time frame for the existence of a species. There are two methods of determining the age of fossils.
   a. In **relative dating** the exact age of the fossil cannot be determined, only the order of appearance as compared to other fossils found in nearby rocks. Fossils occur in layers of sedimentary rock. The fossils near the top will be more recent than fossils in lower layers of rock.

Explanation of the fossil diagram:



www.ekcsk12.org/science/ regbio/evolutionqz1.html

   b. **Radioactive dating** gives a more exact age using the natural decay of radioactive isotopes in organisms.

2. **Biochemical similarities** include comparisons of DNA and the resulting amino acid sequences for certain, shared proteins. This is considered one of the most reliable and objective types of evidence used to determine evolutionary relationships. In general, the fewer differences found between two species, the closer the evolutionary relationship.

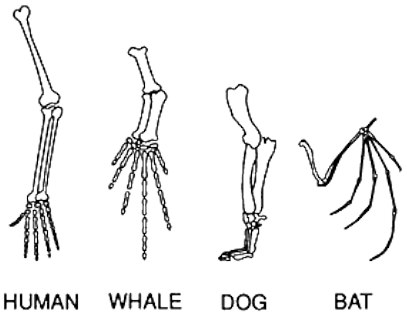
Explanation of the amino acid sequence diagram:

Species	Sequence of Amino Acids in the Same Part of the Hemoglobin Molecules
Human	Lys–Glu–His–Iso
Horse	Arg–Lys–His–Lys
Gorilla	Lys–Glu–His–Lys
Chimpanzee	Lys–Glu–His–Iso
Zebra	Arg–Lys–His–Arg

www.ekcsk12.org/science/ regbio/evolutionqz1.html

3. Shared **anatomical structures** supports some type of evolutionary relationship.
   a. Structures with a similar bone arrangement are called **homologous** structures. A similar bone arrangement, even if the functions are different, supports evolution from a common ancestor.

Explanation of the bone diagram:



www.ekcsk12.org/science/ regbio/evolutionqz1.html

b. Structures that perform the same function (ex. flying) but are very different anatomically (ex. bird wing vs. butterfly wing) are called **analogous** structures. This supports evolution in similar habitats though not from a recent common ancestor.

c. **Vestigial** structures (ex. appendix or tail bone in human) are not functional in that organism, but may represent a link to a previous ancestor.

Example of vestigial structure:

Check Yourself!

1. Name the two methods by which fossils may be dated.

2. How do biochemical similarities support the theory of evolution?

3. What does similar bone structure (even if the function is different) suggest about two species?

III. Does evolution still happen today?

A. As long as variation, overproduction, competition, natural selection and mutations occur, evolution will occur. Because evolution leading to speciation happens over such a long period of time, speciation is not readily observable within a lab.

B. Natural selection, one of the main mechanisms of evolution, is observable in some populations. For example, the evolution of **resistance** to chemicals:

1. Farmers use pesticides to eliminate insects. In a population of insects, some individuals will possess genetic immunity to certain chemicals. When the chemicals are applied, the individuals with genetic immunity will survive and reproduce, passing this resistance to the next

generation of offspring. Over time, more individuals are born with this immunity, rendering the pesticide useless.

2. Antibiotics are drugs that fight bacterial infections. Within any population there is genetic variation. In the case of antibiotic resistance, some bacteria are genetically more resistant to the antibiotic than other bacteria. If the amount of antibiotic delivered is too low or the full course not completed, only those least resistant will die. The surviving, resistant bacteria will reproduce. With future applications of antibiotics the population is selected to become more and more resistant. The overuse of antibiotics has led to many resistant strains of bacteria.

Definition of antibiotic resistance:

CAUSE of resistance:

EFFECT of resistance:

Check Yourself!

1. What is a pesticide?

2. Why do some insects become resistant to pesticides?

3. What is an antibiotic?

4. What has led to the many resistant strains of bacteria?

_____

Immigration

Chance events

3 sources of _____

Genetic Variation within a population

_____ of offspring within population

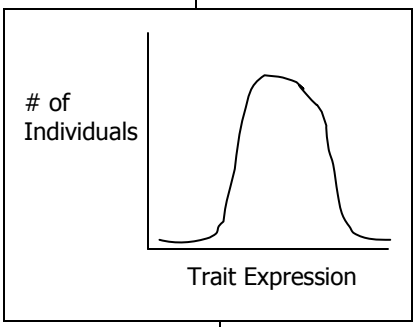
_____ for Resources within the population

_____ of the best adapted individuals.
Possible outcomes

Steps in the process of _____ _____

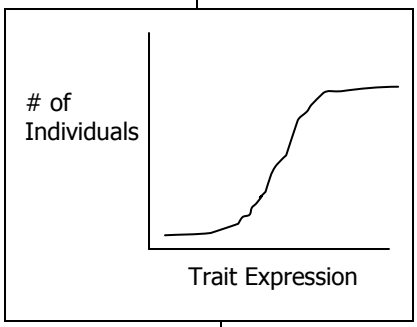
Word Bank:
Average
Both extreme
Competition
Genetic variation
Mutation
Natural Selection
One extreme
Overproduction
Survival and Reproduction

If nature favors the _____form of the trait



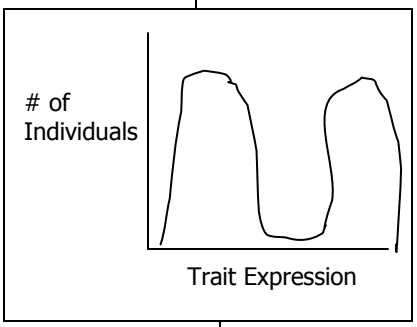
Stabilizing Selection

If nature favors _____ _____form of the trait



Directional Selection

If nature favors _____ _____forms of the trait



Disruptive Selection

Unit 4 / Module 10
Problem-Solving Set

1. Sequence the evolution of cells according to the heterotroph hypothesis:
   i) Prokaryotic, heterotrophic, anaerobic
   ii) _____(release of free oxygen)
   iii) _____
   iv) Eukaryotic

2. Explain the evolution of eukaryotic cells according to the endosymbiont hypothesis:
   _____
   _____
   _____

3. Use Darwin's four points of natural selection to explain the evolution of a long neck in giraffes. The first step has been done for you:

a. Variation	*In a population of giraffes, there is variation in neck length. Some will have short necks, some medium, and some long.*
b. Overproduction/ Competition	
c. Natural Selection	
d. Survival of the best adapted	

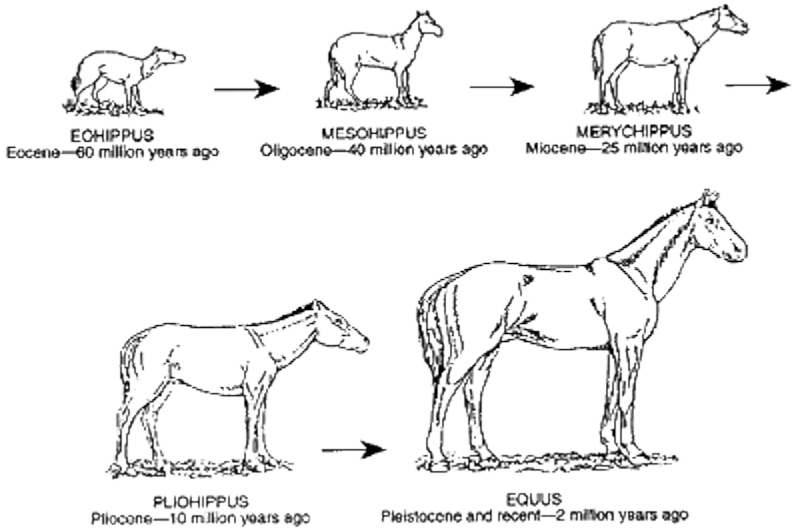
4. List 4 specific adaptations in plants or animals. For example, you might say that porcupines have quills for protection.
   a.

   b.

   c.

   d.

5. The fossil record gives us evidence for evolution by showing us how living organisms have changed over time. Observe the diagram of the evolution of the horse:



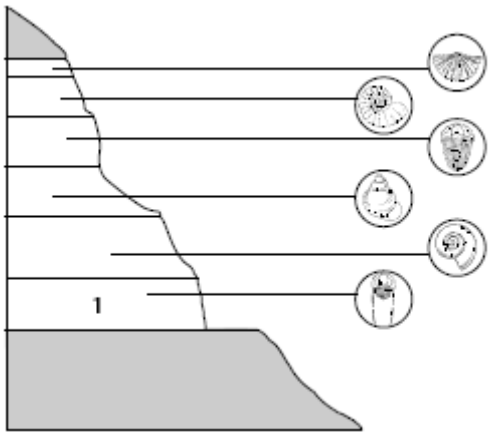
According the fossil record, how have horses changed in 60 million years?

_____

_____

_____

6. On the diagram, number the fossil layers in the order that they were formed:



Number the fossils in the correct order:

Suppose that you found a fossil of the same species as fossil #1 in a rock layer in another location. What could you conclude about the age of that rock layer? _____

_____

7. Biochemical similarities also provide evidence for evolution. The chart below shows similarities in amino acid sequences in hemoglobin for several species.

	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
Human	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Chimpanzee	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Gorilla	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Rhesus monkey	GLN	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Horse	ALA	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Kangaroo	LYS	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU

	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Human	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Gorilla	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Rhesus monkey	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Horse	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	ALA	LEU	VAL	VAL	ALA	ARG
Kangaroo	ASN	PHE	LYS	LEU	LEU	GLY	ASN	ILE	ILE	VAL	ILE	CYS	LEU	ALA	GLU

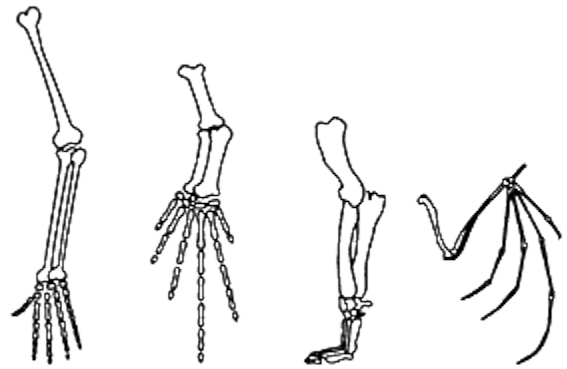
Human hemoglobin is being used as the standard for comparison.

Species comparison	**# similarities**	**# differences**
Human/Chimpanzee		
Human/ Gorilla		
Human/ Rhesus monkey		
Human / Horse		
Human/ Kangaroo		

a. According to the information in the chart, which species have the closet relationship to humans? _____

b. Which species is least related to humans? _____

8. Structural similarities also provide evidence for evolution.



HUMAN WHALE DOG BAT

a. Describe how the bones shown in the diagram are structurally similar to one another.

_____

_____

_____

b. What does the diagram tell us about the relationship of human to the other species pictured?

_____

_____

_____

9. For each of the following scenarios, identify the <u>type</u> of natural selection that is occurring in that environment.

Example	Type of Selection
In woodpeckers, the birds with the longest bills get the most insects. Those with medium bills can't get quite enough to thrive, and those with the shortest bills have little chance of survival.	
In some species of spiders, medium size is best. The smallest are unable to successfully compete for resources and the largest are easily spotted by predators.	
Limpets are shelled invertebrates that attach themselves to rocks. In the areas that they are found, the rocks are generally quite light in color or quite dark. Therefore, the light and dark colored limpets camouflage well on these rocks, while those medium in color are easily spotted by predators.	

10. <u>Read the paragraph and answer the questions that follow:</u>

> Along the North rim of the Grand Canyon lives the black Kaibab squirrel. Across the canyon on the opposite rim lives the Abert squirrel. Both species have big, tufted ears. However, the Kaibab has a flashy white tail and the Abert has a grey tail and body and a white belly. Scientists believe that these two different species of squirrels were once one population that was divided as the Grand Canyon developed. Through natural selection, the squirrels on either side of the canyon developed different characteristics. These two species of squirrel are separated by an environment that is totally different than on either rim of the canyon. The temperature on the rims is cool, but in the canyon it is much warmer and drier. Therefore, the squirrels do not cross the canyon and the populations remain separated.

   a. What isolates the populations of the Kaibab and Abert squirrels? _____
   b. What is the term for the development of a new species? _____
   c. What mechanism led to the development of these two new species of squirrels? _____

11. Identify each of the following examples as gradualism or punctuated equilibrium:

Example	Time frame
Elephants are believed to have evolved from the prehistoric wooly mammoth. Fossil evidence shows little change from the mammoth fossils until the appearance of the Asian and African elephants.	
Fossils of horses and their ancestors show evidence of small changes over a long period of time. They have gotten taller, toes changed to hooves, and teeth became larger and flatter.	

<u>Image credits:</u>
www.ekcsk12.org/science/ regbio/evolutionqz1.html
www.orbro.com/ miclimb/fulldoc.html
www.phsuccessnet.com

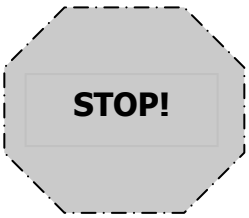
Unit 4: Evolution and Classification

Module 11: Classification

NC Essential Standard:
- 3.5 Analyze how classification systems are developed upon speciation

True or False …What do you think?

1. Living things are classified based on behavior and habitat.
2. New species are being discovered even today.
3. Organisms that have variation in certain traits (for example different breeds of dogs) are classified as different species.
4. Humans are more closely related to fungi than they are to plants.
5. Humans are more closely related to insects than they are to snakes.
6. When a new organism is discovered, it is named based on its appearance alone.
7. Every living organism on earth can be classified as either a plant or an animal.



I. Isn't everything living thing either a plant or an animal?

A. Aristotle is credited with the first true classification system. He grouped all living things into two basic groups: plant and animal.

B. Linnaeus further classified plants and animals by dividing them into related groups. He used the Latin language, because Latin was not longer spoken conversationally and thus was less likely to change.

1. He first grouped related organisms. He called this a **genus**. For example, all of the dog-like creatures were grouped as the genus Canis.
2. He next gave every different type of organism in the group a specific name, which he called **specie.** For example, the dog became Canis familiaris and the wolf Canis lupus. Notice the genus is capitalized but the specie begins with a lower case letter! Both are italicized or underlined.

Write a definition for the word "classify".

The History of Classification:

Linnaeus had ___ kingdoms

↓

Whittaker used _____ kingdoms

↓

Today we use ___ kingdoms

3. Every organism was given a two-word name, the genus and specie. This practice of **binomial nomenclature** continues today, giving each organism a "scientific name".
4. The benefit of binomial nomenclature includes eliminating confusion due to common names (ex. cottonmouth and water moccasin are actually the same animal) and allows scientists around the world to more easily communicate.

C. Even after the microbial world was discovered, the two "kingdom" system continued. (Science can be very slow to change.)

D. As knowledge of the diversity of organisms increased, Whittaker (in 1969) expanded classification to include five kingdoms.

E. The science of classification, **taxonomy**, now allowed scientists to assign seven levels of classification, or **taxa** to living organisms:

MEMORY AID!
K -
P -
C -
O -
F -
G -
S -

Level/Taxa	**Example 1:Human**	**Example 2: Dog**
Kingdom	Animalia	Animalia
Phylum/Division	Chordata	Chordata
Class	Mammalia	Mammalia
Order	Primate	Carnivora
Family	Hominidae	Canidae
Genus	Homo	Canis
Specie	sapien	familiaris

1. The kingdom is the most general of these seven taxa, thus the kingdom would contain the greatest number of organisms.
2. Specie is the most specific of these seven taxa, thus the specie would contain only one type of organism. A specie is defined as a group of organisms which can interbreed and produce fertile offspring.

How are the terms "kingdoms" and "taxa" related?

Draw a picture for each of the six kingdoms and label with the kingdom name:

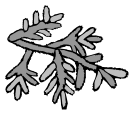
F. Today, we use three **domains**, which are divided into six kingdoms. These domains are based on new information about possible evolutionary relationships.

Domain	**Kingdom**	**Example(s)**
Prokarya/Bacteria	Eubacteria	E. coli
Archaea	Archaebacteria	Thermophile
Eukarya	Protista	Algae, Amoeba
	Plantae	Moss, Fern, Tree
	Fungi	Mushroom, yeast
	Animalia	Sponge, Worm, Human

II. What happens when you find an unknown organism?

A. **Dichotomous keys** are tools that use a series of paired statements and the visible characteristics of the organism. Of course, a dichotomous key is only useful if the organism has already been classified and given a scientific name.

1. Always start at statement 1 (or the beginning point)
2. Decide which path best describes the organism (Statement A or Statement B)
3. Follow that path to find the next choice (Go to …)
4. When you can go no further, you will find the name!

1,  2.  3.  4.  5. 

Answers:
1.
2.
3.
4.
5.

1. a. Organism is a plant ..... go to 2
   b. Organism is an animal ..... go to 3
2. a. Leaves are on a branch ..... Spruce
   b. Leaves grow from ground .....Cattail
3. a. Has wings ..... Mosquito
   b. No wings ..... go to 4
4. a. Has webbed feet ..... Amphibian
   b. No webbed feet ..... Muskrat

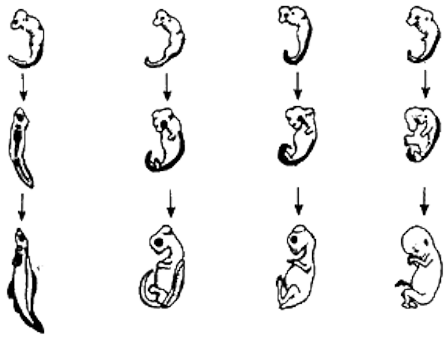
B. If the organism has NOT been classified, taxonomists must begin the process of classification. In order to correctly classify an organism, scientists use many modern tools:

WORD HELP!

"Morph" means _____

"ology" means _____

1. **Morphology** describes the physical characteristics of an organism. Typically, this is enough information to place the organism within a domain and kingdom.
   Example: Presence of a nucleus places the organism in Domain Eukarya
2. DNA and **biochemical analysis** allow scientists to test less visible, but distinguishing, characteristics.
   Example: Gram staining a bacteria cell allows scientists to distinguish between archaea and prokarya
3. Comparing **embryology** allows scientists to group organisms that share common fetal development.
   Example: The diagram below would suggest the last two organisms are most closely related.



www.ekcsk12.org/science/ regbio/evolutionqz1.html

The four things we can compare to classify:

1. _____

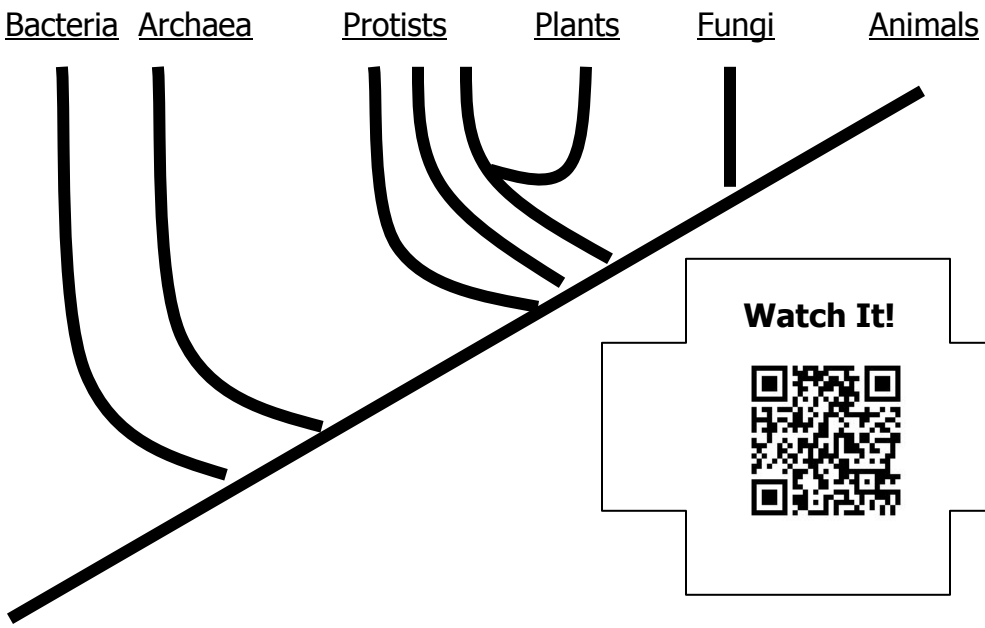
2. _____

3. _____

4. _____

4. **Evolutionary phylogeny** describes the evolutionary relationships between organisms. These relationships are deduced based on **shared traits** that may have been passed from ancestor to new species. Traits may include physical traits (ex. presence of jaws), or may be genetic

traits (shared genes). These relationships can be illustrated in a **phylogenetic tree** or **cladogram**:



In this cladogram, what kingdom is most closely related to animals?

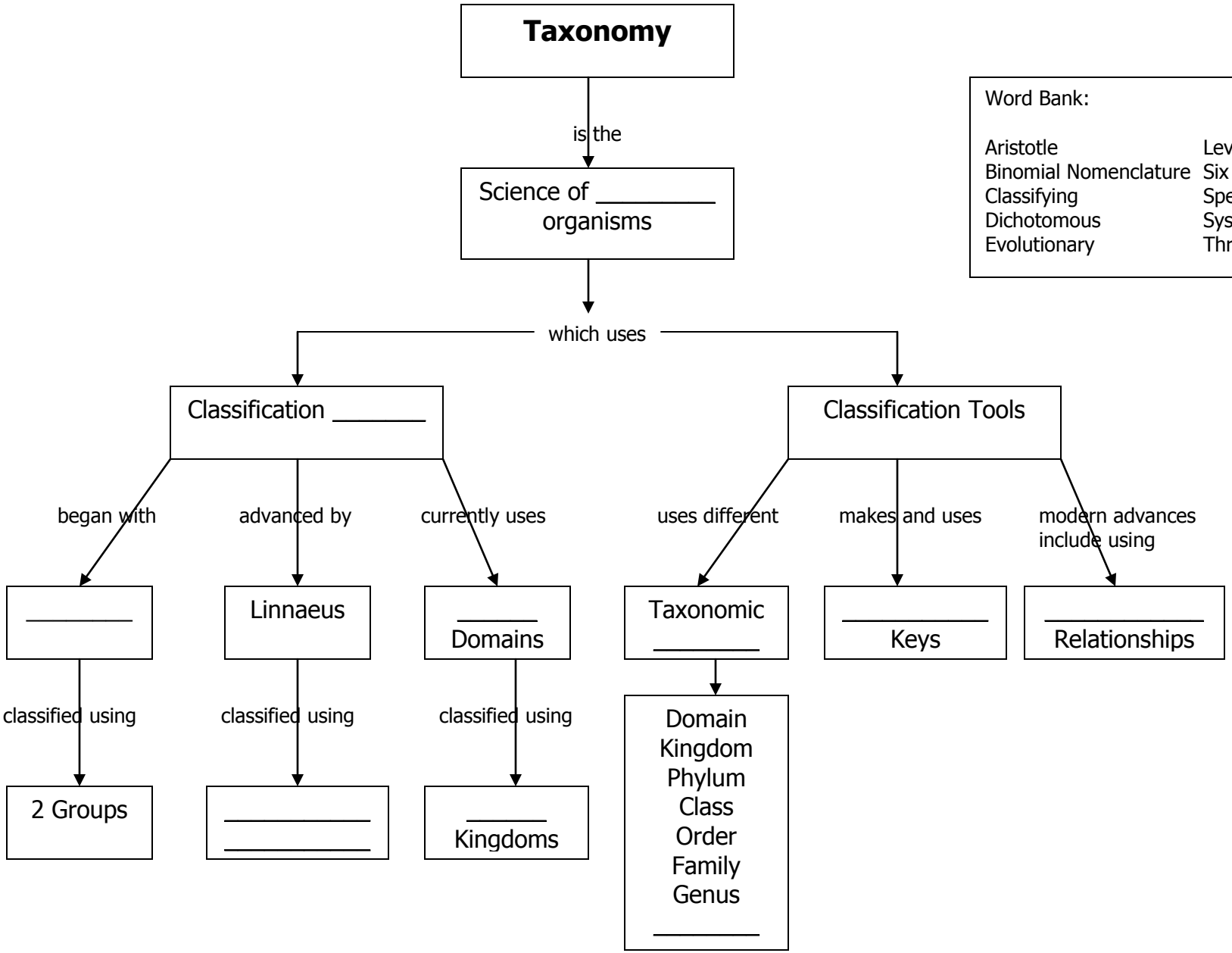
What kingdom evolved first?

From what kingdom did plants evolve?

Watch It!

Check Yourself!

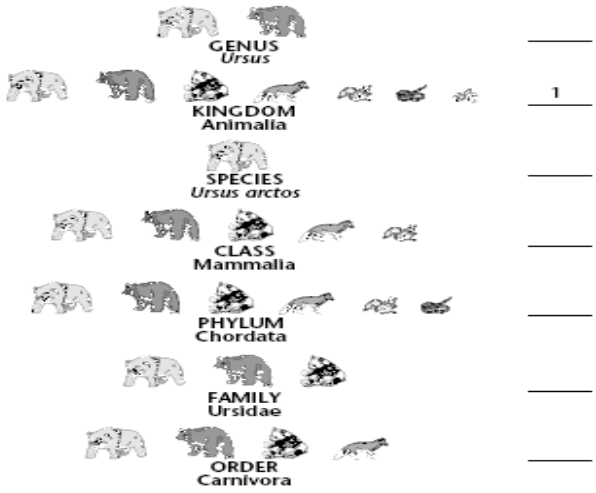
1. Who first officially classified organisms?
2. What was the contribution of Linneaus to taxonomy?
3. What are the two parts of a scientific name?
4. What are the domains used in the current classification system?
5. How many kingdoms are used in the current classification system?
6. What is a dichotomous key?
7. What 4 modern tools are used to classify a newly discovered organism?



Unit 4 / Module 11

Problem-Solving Set

1. The following diagram shows the levels of classification for a polar bear, but they are out of order.
   a. Put the classification levels in the correct sequence:



_____
1
_____
_____
_____
_____
_____

   b. Using binomial nomenclature, give the scientific name of a polar bear based on the words above.

      _____

2. The table below shows the classification taxa for four different organisms. Examine the table, and answer the questions that follow.

Taxa	House cat	Mountain Lion	Domestic Dog	Human
Kingdom	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata	Chordata
Class	Mammalia	Mammalia	Mammalia	Mammalia
Order	Carnivora	Carnivora	Carnivora	Primates
Family	Felidae	Felidae	Canidae	Hominidae
Genus	Felis	Felis	Canis	Homo
Species	domesticus	concolor	familiaris	sapiens

   a. Which two organisms are most closely related?

      _____

   b. Is the dog more closely related to the mountain lion or the human?

      _____

   c. Which three taxa do all of the organisms have in common?

      _____

   d. At what level do humans diverge from the other organisms?

      _____

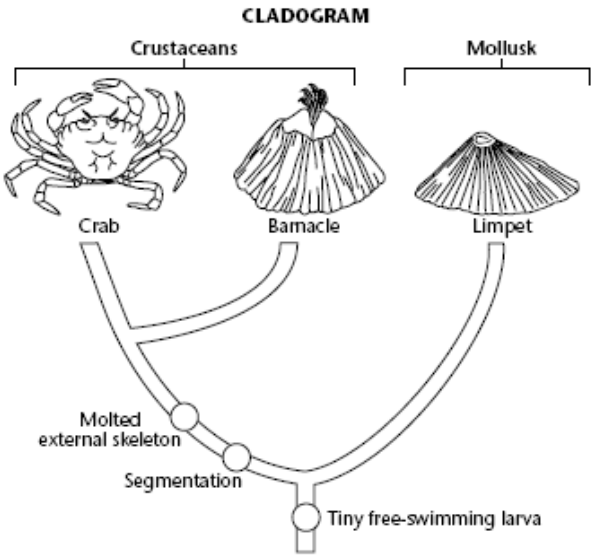
3. Use the dichotomous key to identify the leaves below:

1. a. Leaf is compound (divided into leaflets).....go to 2
   b. Leaf is simple (not divided into leaflets).....go to 4
2. a. Palmate arrangement of leaflets
   (attached at one central point).....Aesculus (buckeye)
   b. Pinnate arrangement of leaflets
   (leaflets attached at several points).....go to 3
3. a. Leaflets taper to pointed tips.....Carya (pecan)
   b. Oval leaflets with rounded tips.....Robinia (locust)
4. a. Leaf veins branch out from one central point.....go to 5
   b. Veins branch from main vein in middle of leaf.....go to 6
5. a. Leaf is heart-shaped.....Cercis (redbud)
   b. Leaf is star-shaped.....Liquidambar (sweet gum)
6. a. Leaf has toothed (jagged) edge.....Betula (birch)
   b. Leaf has untoothed (smooth) edge.....Magnolia (magnolia)

Leaf #	Leaf Name
I	
II	
III	
IV	
V	
VI	
VII	

Image credits
www.phsuccessnet.com

4. The cladogram below shows evolutionary relationships of 3 species. Use the cladogram to answer the questions that follow.



a. What characteristics do all three species have in common?
_____

b. What characteristics are only displayed by crabs and barnacles?
_____

c. To which organism is the crab more closely related? (circle one)
Limpet Barnacle

d. Mark an "X" at the point on the diagram that shows the most recent common ancestor of crabs and barnacles.

e. Mark an "O" at the point on the diagram that shows the most recent common ancestor of mollusks and crustaceans

Unit 5: The Kingdoms of Life

Module 12: "Simple" Organisms

NC Essential Standard:
- 2.1.2 Analyze how various organisms accomplish life functions

STOP!

True or False …What do you think?

1. All microorganisms are "germs" and are therefore harmful.
2. Viruses and bacteria are the same type of organism.
3. Viruses are not true living things.
4. Some bacteria live in our bodies and are good for us.
5. A single celled organism is not able to carry out the STERNGRR processes.
6. Trees provide most of the oxygen on earth.
7. Malaria is caused by mosquitoes.
8. Fungi cannot photosynthesize.
9. Fungi are a type of plant.
10. Some fungi can be eaten.

I. Is a virus a living thing?

A. **Viruses**, although not technically living due to the lack of cellular structure, are classified as microorganisms.

B. Viruses are composed of a protein coat (called a **capsid**) that protects a nucleic acid - either DNA or RNA. The shape of the capsid determines the type of cell the virus can infect.

C. A virus can only exist by infecting a host cell. Viruses are classified by the reproductive cycle it uses to infect the host cell.

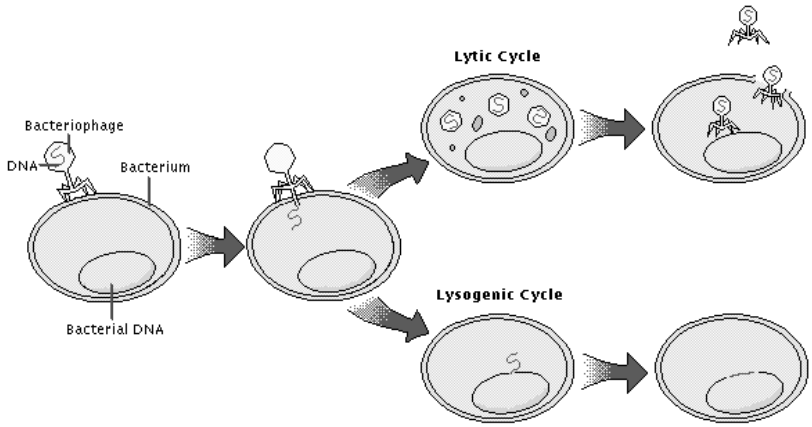
1. The **lytic cycle** describes the "life cycle" in which a virus uses the host cell to make copies of itself, then quickly kills the host cell as new virus copies are released.
2. The **lysogenic cycle** describes the "life cycle" in which the virus has a dormant stage in which the virus remains inactive within the cell. This dormant period may last for weeks, months, or years. An environmental trigger may cause the viral DNA to emerge from the host DNA and begin a lytic cycle of reproduction.

Name 2 reasons that viruses are not considered living things:

1.

2.

Using the diagram, explain how lytic and lysogenic are different:



http://images.encarta.msn.com/xrefmedia/aencmed/targets/illus/ilt/T012837A.gif

D. Viruses are **pathogenic**, or disease-causing microorganisms.

1. HIV causes AIDS. HIV infects T-cells, which are important for the immune response. Thus, people with AIDS often die of opportunistic infections, such as pneumonia.
2. Several different viruses cause influenza (the "flu"). Influenza viruses infect respiratory cells. The lysis of these cells leads to some of the typical symptoms of the flu, such as sore throat and congestion.
3. A poxvirus causes smallpox. Smallpox starts in the cells of the lymph nodes and lungs. Symptoms include severe headaches, muscle ache, and pustules on the skin.

Identify 3 viral diseases:

1.

2.

3.

E. Virus Prevention and Treatment

Differentiate between active and passive immunity:

1. Vaccines can be developed for viral diseases. A vaccine uses a dead or weakened form of the virus to "turn on" the immune response so that antibodies are produced.
   a. Active immunity to a virus is conferred by a vaccine or by exposure to the virus itself.
   b. Passive immunity is conferred when antibodies are passed between individuals (ie. through breast milk).
2. Antiviral medications work by interrupting the virus's life cycle. Antibiotics are NOT effective against viruses!

F. Viruses and Natural Selection

1. Viruses often mutate rapidly, meaning the actual virus being spread changes with each outbreak.
2. Mutations in the HIV virus make developing a treatment or vaccine difficult. Viruses that are resistant due to mutations can survive and reproduce by natural selection.
3. Flu epidemics are caused by viruses that are genetically different enough from earlier years' viruses that people have little immunity to them.

Check Yourself!

1. What are the two parts of a virus?
2. What are the two reproductive cycles of viruses?
3. What is a pathogen?
4. What type of cell does HIV infect?
5. Why is there a different flu virus each year?

II. Are all bacteria "bad"?

A. All **bacteria** are classified in the kingdoms **Eubacteria** and **Archaebacteria**. They are differentiated by the chemicals found in the bacterial cell wall. They are all unicellular and prokaryotic.

B. Bacteria reproduce through **binary fission**, but can also exchange DNA by **conjugation**. This allows for genetic variation.

C. The vast majority of bacteria in our world are beneficial. They are important decomposers and perform many other ecosystem services. They exist in the intestines of some animals and aid digestion. They are also important in food production.

Identify 3 ways that bacteria are beneficial:

1.

2.

3.

D. Some bacteria are pathogenic. One example is the bacterium *Mycobacterium tuberculosis*, which causes tuberculosis. The disease attacks the lungs and causes coughing, chest pain, fatigue and fever – it can be fatal if not treated. This bacterium causes disease because it destroys cells. The cells are broken down by the

bacteria as a source of nutrition. Other bacteria harm the host by releasing toxins such the bacterium that causes food poisoning.

E. Pathogenic bacteria can be treated with antibiotics. Antibiotics kill the bacteria by destroying the cell wall. Bacteria that are resistant to antibiotics can survive and reproduce by natural selection. This means that new antibiotics must continually be developed.

Check Yourself!

1. Which two kingdoms include bacteria?
2. How do bacteria reproduce?
3. Name two ways that bacteria cause illness.

III. What is a Protist?

Watch It!

A. **Protista** is a diverse kingdom of organisms that is divided into 3 main groups: algae (plant-like), protozoa (animal-like) and slime molds (fungus-like).

B. **Algae** are important aquatic producers (the base of aquatic food webs) and produce most of earth's oxygen. They may be unicellular or multicellular (seaweed).

C. **Protozoa** are unicellular, aquatic protists that are similar to animals. Protozoa have adaptations to allow them to accomplish life functions:

1. Adaptations for movement include a whip-like tail called a **flagellum**, tiny hair-like projections called **cilia**, or extensions of the cell membrane called **pseudopodia**.
2. An adaptation for water balance is the **contractile vacuole**. This vacuole pumps excess water out of the cell, since these aquatic organisms may take in more water than necessary by osmosis.
3. An adaptation for response to stimuli is the **eyespot**. This structure allows for responses to light.

Draw a simple diagram of a paramecium. Label the cilia, contractile vacuole, and eyespot.

D. In protozoa, reproduction is asexual through binary fission, and many algae use fragmentation. Some protists may exchange DNA though conjugation.

E. Some protists are pathogenic. Malaria is a disease caused by parasitic protists called plasmodia. Malaria is transmitted by a mosquito. Any organism which transmits/carries a disease without being affected by the disease is called a vector. The symptoms of malaria include headache, shaking, chills, and fever. Some forms of malaria may lead to comas, convulsions, or even death.

Check Yourself!

1. What are the 3 groups of protists?
2. Name 2 reasons that algae are important.
3. What protist causes the disease malaria?

IV. How are fungi different from plants?

A. **Fungi** are eukaryotic organisms that may be uni- or multicellular.

B. Fungi are heterotrophic. They obtain food through **extracellular digestion**, secreting digestive chemicals and absorbing nutrients.

List 2 ways that fungi can reproduce:

1.

2.

C. Fungi may reproduce asexually, such as **budding** in yeast. **Spores** may be used for asexual or sexual reproduction.

D. Some fungi are pathogenic. Candida is yeast that is a normal inhabitant of moist human epithelial tissue, such as the throat and vagina. Certain circumstances can cause Candida to become pathogenic by growing too rapidly and releasing harmful substances. This leads to conditions such as oral thrush, yeast infections, and/or kidney infections.

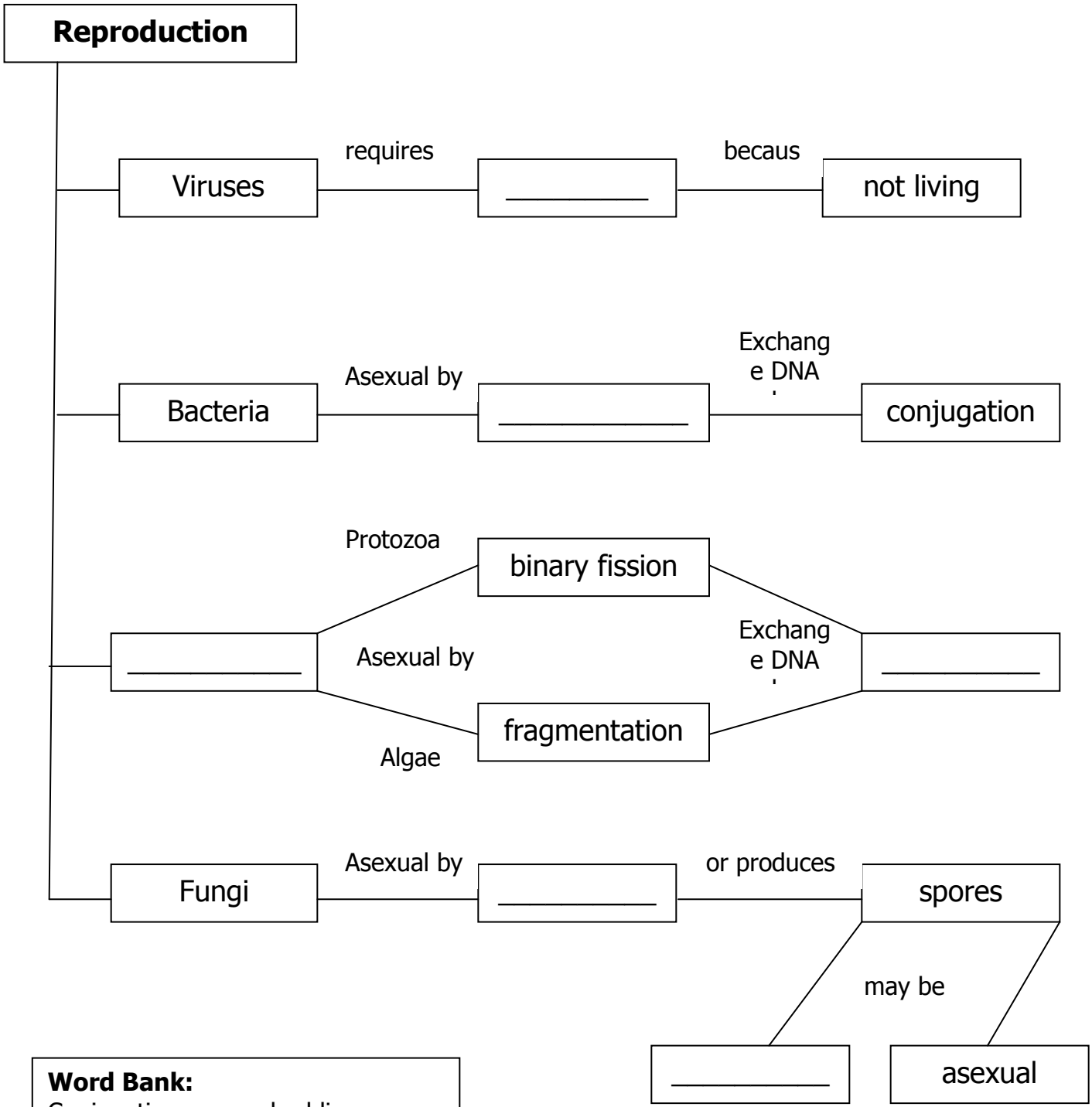
Check Yourself!

1. How do fungi obtain food?

2. What reproductive structure can be used for sexual or asexual reproduction?

3. What is the name of the fungus that causes thrush?

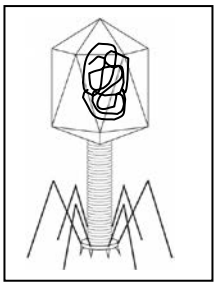
Concept Map: Reproduction of Simple Organisms



Word Bank:

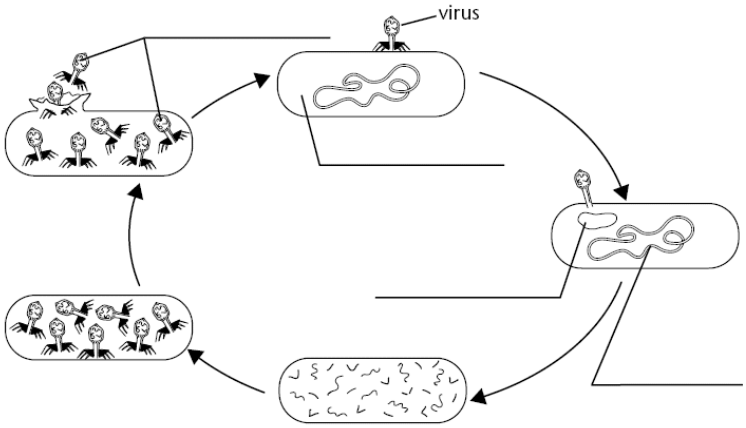
Conjugation	budding
Sexual	host
Protists	binary fission

Unit 5 / Module 12
Problem Solving Set

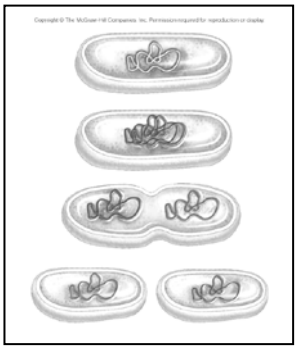


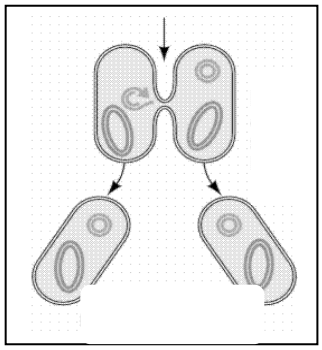
1. On the picture of the virus, label the capsid and nucleic acid.

2. On the viral reproduction diagram, label:
   Host cell, Virus, Viral DNA, and Bacterial (host) DNA



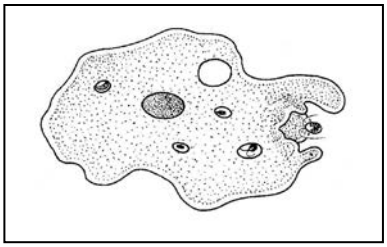
3. Label what is occurring in each diagram of bacterial reproduction:

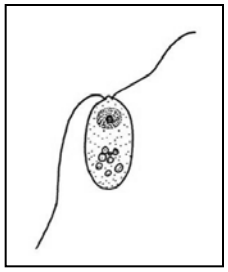


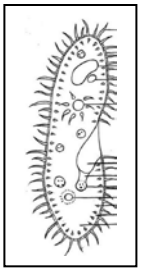


_____ _____

4. Identify the type of movement being used by the protists in the diagrams.

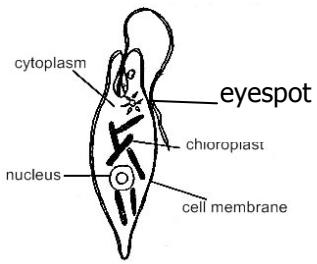






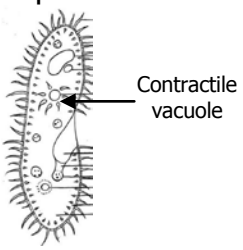
_____ _____ _____

5. The *Euglena* shown below is a protist that has the ability to move (animal-like) but also contains chloroplasts (plant-like). Explain the importance of the EYESPOT for this organism.



Importance of eyespot:

6. The paramecium shown below lives in a freshwater environment. Explain the importance of the contractile vacuole for this organism.



Importance of contractile vacuole:

7. Complete the chart below on the benefits of "simple organisms":

Organism	**Ways this organism is beneficial**
Bacteria	
Protists	
Fungi	

8. Complete the chart for the following diseases. The cause should be the pathogen (for example, virus or bacteria or fungus or protist).

Disease	**Cause (pathogen)**	**Effects (symptoms/signs)**	**Treatment/ Prevention**
HIV			
Influenza			
Smallpox			
Tuberculosis			
Malaria			
Thrush			

Unit 5: The Kingdoms of Life

Module 13: Plants

NC Essential Standard:
- 2.1.2 Analyze how various organisms accomplish life functions

True or False …What do you think?

1. Plants use the sun as food.
2. Plants use heat from the sun as a source of energy for photosynthesis.
3. Plants absorb water through their leaves.
4. Minerals from the soil are taken in by the roots.
5. Some plants are autotrophs and some are heterotrophs.
6. Plants reproduce sexually using sperm and egg.
7. Plants do not move and are therefore unable to respond to stimuli.
8. All plants have roots, stems, and leaves.
9. Plants have methods to excrete waste.
10. Plants produce oxygen for the benefit of humans and other animals.

STOP!

I. Are all plants the same?

A. All plants share some common characteristics.

1. All plants are photosynthetic autotrophs. In order to photosynthesize, plants use special cell structures called chloroplasts. Chloroplasts are filled with a pigment called chlorophyll that transfers light energy into chemical energy. The plant then uses the energy to make sugars, which store the energy for later use in respiration.
2. All plants are multicellular. Plants are made of eukaryotic cells with cell walls surrounding the cell membrane for protection against cell lysis, large vacuoles near the center of the cell to store water, and chloroplasts in specialized cells within the plant body.
3. Plants are common producers in ecosystems, forming the base of all terrestrial food webs.

Sketch of a chloroplast:

Chlorophyll _____ green light and _____ all other wavelengths.

B. Plants are divided into groups based on differing characteristics.

Outline of plant types:
I.

II.

A.

B.

1.

2.

1. The first main division of plants is based on the presence of vascular tissue. **Vascular tissue** consists of specialized cells joined into tubes that aid the plant in moving water and nutrients throughout the plant body.
   a. Nonvascular plants lack vascular tissue.
   b. Vascular plants have two basic types of vascular tissue: xylem (which carries water) and phloem (which carries nutrients).
2. Vascular plants can be further divided based on the means of reproduction:
   a. Seedless vascular plants reproduce using spores (ex. fern).
   b. **Gymnosperms** are vascular plants which store seeds in cones (ex. spruce).
   c. **Angiosperms** are vascular plants which store seeds in fruits which develop from flowers (ex. daisy).

Check Yourself!
1. Name three characteristics shared by all plants.

2. What are the two main divisions of plants?

3. How are vascular plants further sub-divided?

4. What is an angiosperm?

II. Are plants alive?

A. Transport describes how plants get what they need to the cells and remove wastes from the cells.

1. Non-vascular plants depend on osmosis to take in water and diffusion to move other important substances (sugars) to the cells. Therefore, the plant must be small and grow in mats which have a spongy quality which help to absorb and retain water.
2. Vascular plants have a system of tubes and vessels which allow them to transport water and nutrients throughout the plant body. Therefore, the plant can grow much taller.
   a. **Xylem** is the vascular tissue that transports water from the roots to the rest of the plant body.
   b. **Phloem** is the vascular tissue that transports nutrients (sugars produced through photosynthesis) from the photosynthetic structures (ex. leaves) to the rest of the plant body.

Sketch a tree in the space below. Draw and label 2 arrows – one showing xylem and the flow of water, one showing phloem and the flow of food:

B. Respiration describes the process by which plants (and all other cells) transform the stored energy of sugars into the quick energy of ATP. In order to respire plants need to obtain oxygen (from environment and/or photosynthesis) and sugars (from photosynthesis).

C. Excretion describes how the plant rids itself of wastes.
   1. Non-vascular and vascular plants get rid of gaseous waste by diffusion. Vascular plants, however, have special microscopic openings on the surface of the leaves through which the diffusion takes place. These openings are called **stomata** and are formed by two adjacent **guard cells**.
   2. Plants can also store waste in the vacuole or in organs which are destined to fall off or die (ex. leaves in the autumn). Some plants excrete waste products into the soil, occasionally using the wastes as chemical weapons against other competing plants.

Picture of stoma and guard cells, showing diffusion of O^2 and CO^2

Check Yourself!

1. How do non-vascular plants transport water?
2. What vascular tissue transports water?
3. What do plants need in order to respire?
4. From where do plants get oxygen for cellular respiration?
5. What are stomata?

D. Synthesis describes how organisms build necessary molecules. Plants produce sugars through photosynthesis which requires gas exchange through the stomata. Plant cells must also produce essential cell molecules such as phospholipids for membranes and proteins for enzymes.

E. Nutrition describes how organisms break down food. The sugar produced in photosynthesis may be stored or moved throughout the plant to be broken down and used during cellular respiration.

F. Regulation describes how organisms control body processes.

1. Plants produce hormones which regulate their growth and development and may control responses to stimuli.
   a. **Auxins** are hormones that allow for elongation of the cell. This increased flexibility allows the plant to bend.
   b. **Cytokinens** are hormones that promote rapid cell division. These hormones are found in rapidly growing regions of the plant such as the apical meristems (plant tissue in root tips and buds of shoots that supply cells for the plant to grow in length).
   c. **Ethylene** is a hormone that promotes fruit ripening. Because ethylene is a gas, it can affect nearby fruit.

Summary of plant hormones:

Name	**Function**
1.	
2.	
3.	

Pictures of:
Phototropism
Gravitropism
Thigmotropism

2. Plant **tropisms** are plant growth responses to external stimuli. These responses are made possible by hormones such as auxin.
   a. **Phototropism** describes a plant's response to light.
      Ex. Leaves and stems grow toward the light to help with photosynthesis.
   b. **Gravitropism/Geotropism** describes a plant's response to gravity.
      Ex. Roots grow toward the force of gravity but stems grow against the force of gravity.
   c. **Thigmotropism** is a response to constant contact.
      Ex. Vines wrap around an object, such as a mailbox.

Check Yourself!

1. Give two examples of important substances plants need to synthesize.

2. How does a plant use the sugar produced in photosynthesis?

3. What regulates the growth and development of plants?

4. What term describes a plant's response to constant contact?

G. Reproduction

1. Some plants may also use asexual reproduction through vegetative propagation. In vegetative propagation a new plant is produced from an existing vegetative structure.
   Ex. Your grandma Agnes in the dark of night went into her neighbors yard to chop off a piece of a hydrangea shrub. She plops the piece of shrub into a bucket of water, where it begins to root. She then plants the rooting stem.

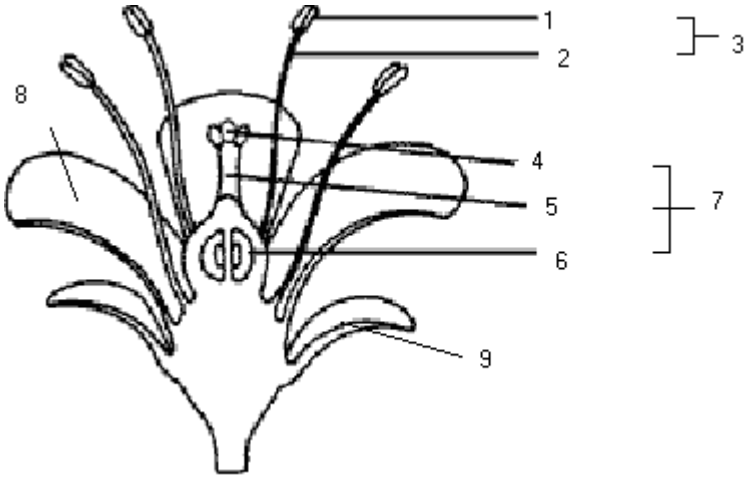
Location of seeds in…
Gymnosperms

Angiosperms

On the flower diagram, COLOR the male parts blue and the female parts red.

Flower Parts Key:
1. Anther
2. Filament
3. Stamen
4. Stigma
5. Style
6. Ovary
7. Pistil/Carpal
8. Petal
9. Sepal

2. Non-vascular plants and seedless vascular plants have sperm and egg on separate structures. The sperm must swim to the egg. This requires a film of moisture. After fertilization a structure develops which contains haploid spores. The spores grow into new plants.
3. Angiosperms and gymnosperms reproduce by means of seeds. Fertilization in seed plants does not require water.
   a. Gymnosperms produce pollen in male cones which fertilizes egg in female cones. The fertilized egg becomes a seed.
   b. Angiosperms use flowers as reproductive structures. The colored petals of a flower or scented/sweet nectar attract pollinators. A flower may contain both male and female parts:



http://www.ekcsk12.org/science/regbio/flowerdiagram.gif

   i. The male reproductive structure is called the **stamen**. The stamen consists of the **anther** and the **filament**. The anther produces **pollen**, containing sperm.

Differentiate between "pollination" and "fertilization".

Watch It!

Sketch a seed that is adapted for dispersal by air:

ii. The female reproductive structure is called the **pistil** or **carpel**. The pistil consists of the **stigma**, the **style**, and the **ovary**. The stigma is sticky, which helps collect pollen. The ovary holds **ovules**, containing eggs.

iii. **Pollination** occurs when the pollen produced by the anther is transferred to the stigma. Pollen may be transferred to the stigma of a flower on a different plant (cross-pollination) or to a stigma of a flower on the same plant (self-pollination).

iv. Fertilization occurs when the pollen reaches and fuses with the egg. To reach the egg, the pollen produces a **pollen tube** using enzymes through the style.

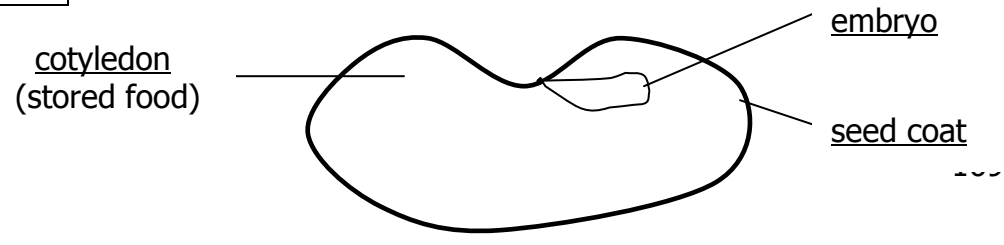
v. The fertilized egg becomes a **seed**. As the seeds form, the ovary swells and ripens to form **fruit**. The fruit aids in seed dispersal.

vi. The seeds are dispersed in a number of ways: air (ex. dandelions), water (coconuts), animals ("hitchhikers" and pooped out).

H. Growth and Development

1. Spore plants produce spores which develop into mature plants.
2. Seed **germination** (the development of the new plant from the embryo) may happen immediately, or after a period of **dormancy** (inactivity).

On the seed diagram, color or highlight the baby plant.



3. The seed is an important adaptation for plants living in terrestrial ecosystems. The seed contains a protective coat, an embryo which is in an arrested state of development, and a relatively large supply of food.

Check Yourself!

1. What structure do nonvascular plants and seedless vascular plants use to produce a new plant?
2. Where are the seeds contained in gymnosperms?
3. What attracts a pollinator to a flower?
4. Name three methods of seed dispersal.
5. What are the three parts of the seed?

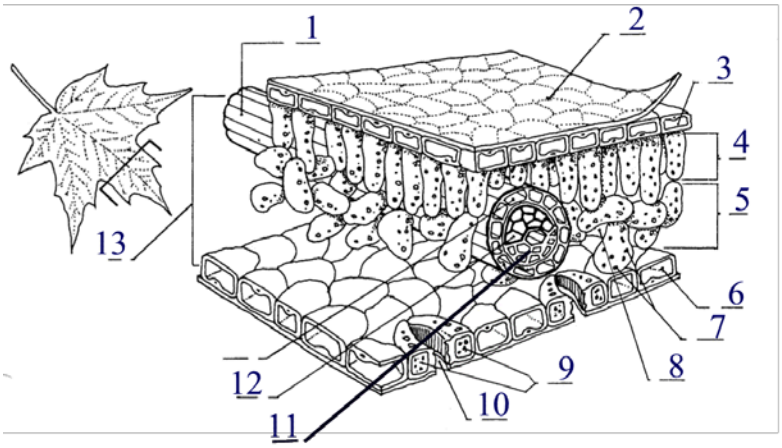
III. What clues can plant structures and behaviors give about the environment?

A. **Leaves** are the main photosynthetic organs of most plants. The structure of a leaf is adapted for many functions.

1. Typical leaf cross section

Leaf Parts Key:

1. Vascular bundle/Vein
2. Cuticle
3. Upper epidermis
4. Palisade mesophyll
5. Spongy mesophyll
6. Lower epidermis
7. Chloroplasts
8. Air space
9. Guard cells
10. Stoma
11. Phloem
12. Xylem
13. Mesophyll layer



http://www.lampstras.k12.pa.us/hschool/teachers/pitts/bio/411bio.htm

a. The **cuticle** is a transparent waxy covering that helps to protect the leaf from water loss. For example, plants that keep their leaves year round, such as pines, have a thick cuticle to protect them from dry winters.
b. The **mesophyll** layer contains cells full of chloroplasts (which capture light energy) and air spaces (which collect carbon dioxide) to maximize the rate of photosynthesis.

The vascular bundle can also be called a _____.

c. The **vascular bundle** is composed of xylem and phloem for the transport of water and nutrients throughout the plant.
d. The **stomata** are openings in the leaves that allow for gas exchange. The opening is regulated by **guard cells** on either side. When open, gas exchange and water loss (**transpiration**) occurs.

2. Specialized leaf adaptations.
   a. The size of the leaf, or the amount of surface area, corresponds to limiting factors in that ecosystem. For example, shade plants have large leaves to increase exposure to sunlight, while plants living in dry climates have reduced surface area to minimize water loss through stomata.

Pine trees have adapted leaves called _____ with reduced surface area to _____ water loss during the dry winter months.

   b. Carnivorous plants have leaves modified to trap insects. For example, the leaves of a Venus Fly Trap quickly respond to touch by closing around the insect, while the leaves of a pitcher plant are curved and slick to trap the insect inside.
   c. Leaves may be modified for protection. For example, cacti have adapted leaves called spines, while holly leaves have sharp points.

B. **Stems** are the organ of the plant responsible for support and for transport of materials. Stems may be adapted for specific plant needs within an ecosystem.

1. A **tuber** is a stem modified for storing food. The food is produced as a simple sugar during photosynthesis and converted to a starch for long term storage. For example, potatoes are underground stems modified for food storage.
2. A **succulent** stem stores water. Plants with a succulent stem typically live in very dry areas. For example, desert cacti have succulent stems.
3. **Tendrils** are structures on stems modified to wind tightly around objects, such as trees or trellis. Tendrils are important for vines to allow them to gain access to sunlight. For example, honeysuckle vines climb using tendrils.
4. **Runners** are stems that grow out to take root and produce new plants. This is a type of asexual reproduction for some plants. For example, strawberry plant "spreads" using runners.

Summary of stem adaptations:

1.

2.

3.

4.

Think about it!
How might the roots, stems, and leaves of a cactus be adapted to the dry desert environment?

- **Roots**
- **Stems**
- **Leaves**

C. The **roots** are the organ responsible for absorbing water, anchoring the plant and may also store food. Roots adaptations often correspond to soil type and plant needs.

1. A **taproot** is a large, main root which is usually joined to many secondary roots. The taproot provides a strong anchor and allows the plant to reach water far below the earth's surface. Some taproots also store food, such as the carrot.
2. **Fibrous roots** are smaller branching roots which increase surface area for quick water absorption. Some fibrous roots systems grow together to form a "mat" system called sod. For example, grasses use fibrous roots.
3. **Root hairs** are specialized cells that increase the surface area of the root to allow for faster absorption of water.

Sketch of root with root hairs:

D. Plants exhibit a number of growth responses and movements that are linked to environmental rhythms. These responses to environmental cues are adaptive and benefit the plant in some way.
   1. Plants may only flower during certain times of the year in response to the number of hours of light and darkness they receive. For example, the amount of day light is greater during the summer months.
   2. During unfavorable seasons, plants may limit their growth or cease to growth all together. This condition of arrested growth is called **dormancy** and enables plants to survive periods of water shortage or low temperatures. For example, **deciduous** trees shed all leaves in the fall.

Check Yourself!

What is the main photosynthetic organ of plants?

2. What waxy leaf structure helps prevent water loss?

3. What occurs when stomata are open?

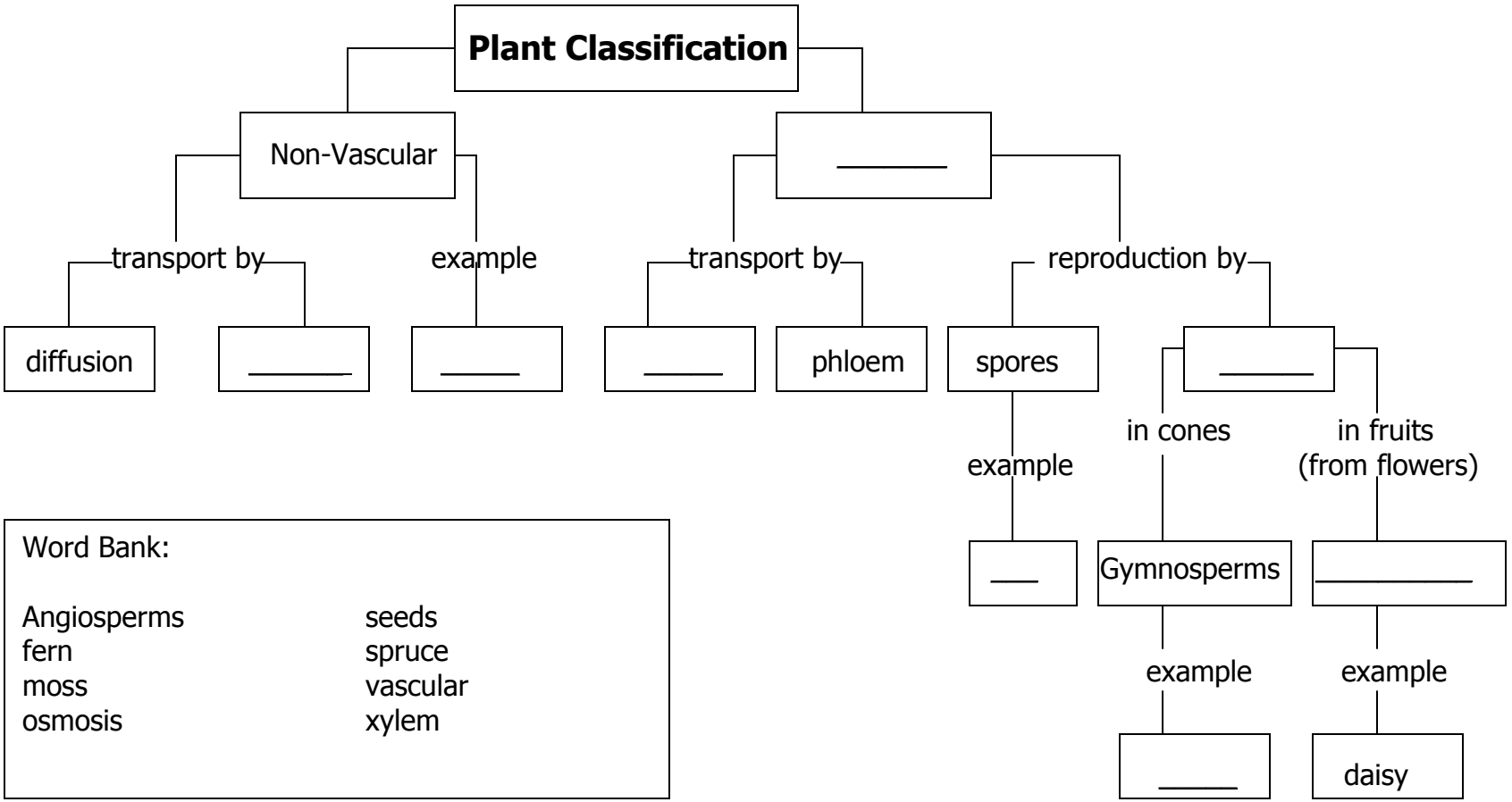
4. Why do plants in dry areas have leaves with reduced surface area?

5. What organ of the plant is responsible for support?

6. What is the purpose of a tuber?

7. What are the functions of roots?

8. What is the benefit of dormancy to plants?

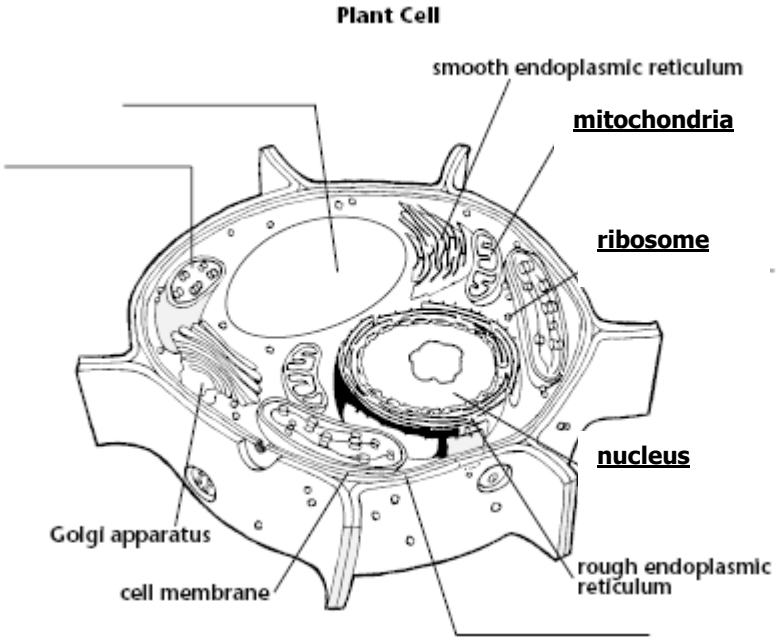


Word Bank:

Angiosperms	seeds
fern	spruce
moss	vascular
osmosis	xylem

Unit 5 / Module 13
Problem-Solving Set

1. Use the diagram of the plant cell to answer the following questions:



   a. Fill in the blanks with the missing terms.

   b. Plant cells are [prokaryotic or eukaryotic]. Circle the correct answer.

2. Give the function of each of the following plant cell parts:
   a. Cell wall _____
   b. Chloroplast _____
   c. Large vacuole _____

3. Identify the plant type based on the characteristics described:

Non-vascular	**Angiosperm**	**Gymnosperm**

   _____ a. You notice that the Christmas tree that your family has chosen has several small cones on the branches.

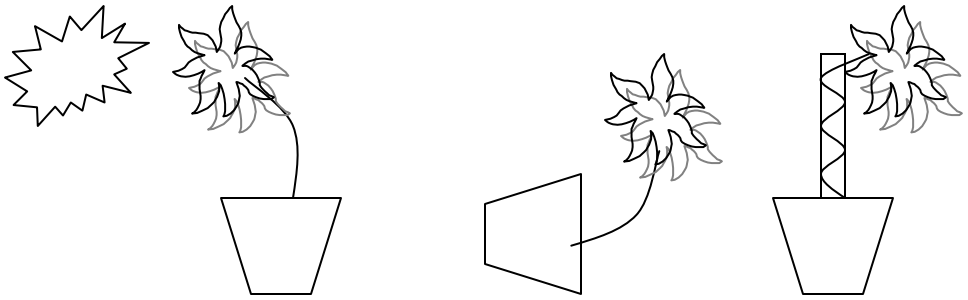
   _____ b. At the base of the large oak tree in your front yard is a very short plant that feels like a spongy mat. It is nearly always damp.

   _____ c. The tomato plants in your Mom's garden start out with tiny yellow flowers, but eventually they disappear and red fruit is produced.

4. Match the descriptions of plant life functions to the correct STERNGRR process. Some of them may be used more than once!

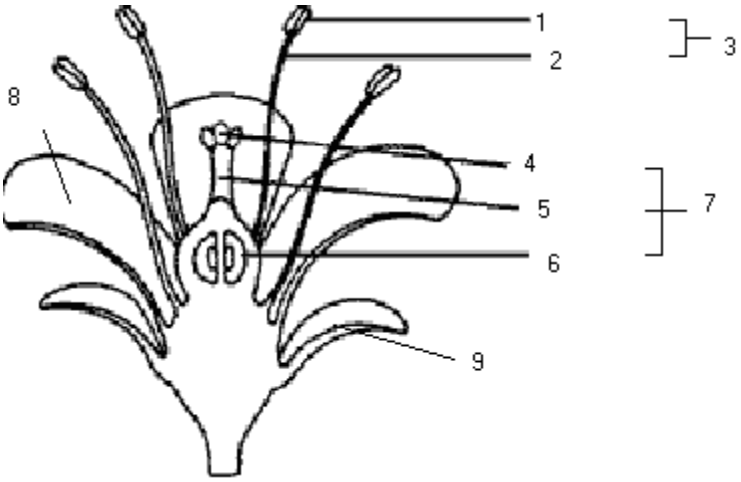
Description	**STERNGRR process**
Stomata open to release oxygen gas and water from blades of grass, creating dew	
Plants use the sugars and oxygen produced during photosynthesis to make ATP	
Potato plants use the sugars made in photosynthesis, and store some as starch for later use	
In honeysuckle, the pistil can be removed from the flower to access the sweet nectar	
Mosses always grow in moist areas so that they may take in water by osmosis	
Apples may ripen more quickly if an overripe apple is placed in a bag with others	
Some plants such as poison ivy may produce chemicals as a defense against predators	
In a tall oak tree, water is moved by the xylem from the roots to the leaves	
The stored wastes in the leaves of maple trees are discarded when the tree loses its leaves in the fall	
An ivy plant is able to wrap around a trellis and grow up the side	
Cuttings from a hydrangea shrub can be rooted and used to produce a new plant	
Ferns have tiny brown spots on the backside of their fronds (leaves) where spores are contained	
Phloem moves sugars from the leaves of a carrot plant to the root, where they may be stored as starch	
Frasier fir trees have cones that may be opened (seeds already released) or closed (seeds contained within)	

5. Identify the type of plant tropism shown in each diagram:



_____ _____ _____

6. Label the diagram of the flower. **Color** the male structures yellow and the female structures pink.



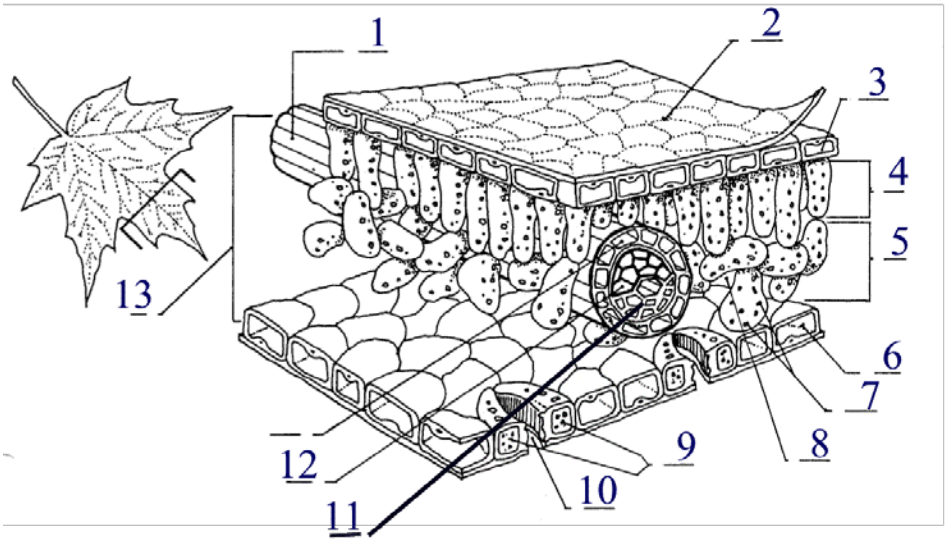
7. Put the steps of flowering plant reproduction in the correct order:

_____ stigma collects pollen
_____ sperm fuses with egg
_____ pollen tube grows through style
_____ seeds are dispersed
_____ ovary swells and ripens
_____ fertilized egg becomes a seed

8. For each of the seed types listed, identify a probable means of seed dispersal: AIR, WATER, or ANIMALS

a. dandelion _____
b. gumball _____
c. coconut _____
d. berry _____

9. Answer the questions about the leaf cross-section below:



_____ a. The structure that transports water and minerals throughout the plant.
_____ b. The structure that helps the leaf to retain water.
_____ c. The structure that is used for gas exchange.
_____ d. The photosynthetic organelle found in leaf cells.
_____ e. The area where carbon dioxide is stored.

10. For each of the environments described, name at least one plant adaptation that would be beneficial.

Environment	Adaptation
Hot and dry desert environments are harsh. Plants must have ways to collect and store water. They also must protect themselves from predators wishing to obtain their stored water.	
In the tropical rain forests, the canopy of trees blocks most of the sunlight. Plants growing from the forest floor must have ways to access sunlight.	
In a temperate deciduous forest, seasons create rapidly changing conditions. Plants must prepare themselves for the lack of resources during the winter season.	

Unit 5: The Kingdoms of Life

Module 14: Animals

NC Essential Standard:
- 2.1.2 Analyze how various organisms accomplish life functions
- 2.1.3 Explain various ways organisms interact with each other

STOP!

True or False …What do you think?

1. Sponges and coral are animals.
2. All animals have a true heart.
3. Digestion is a process that releases usable energy from food.
4. Respiration is synonymous with breathing.
5. All animals are either male or female.
6. Some mammals can lay eggs.
7. Animals are born "knowing" certain behaviors.
8. Automatic responses like blinking are behaviors.
9. Motivation for learning something always comes from a teacher.
10. Humans are the only animals with the ability to communicate.

I. What is an Animal?

A. Multicellular, eukaryotic, heterotrophs that lack cell walls.

B. Broken into two groups:

1. **Invertebrates** (lack a backbone) – 95% of all animals; includes sponges, jellyfish, worms, insects, crustaceans, spiders, and starfish
2. **Vertebrates** (have backbone) – fish, amphibians, reptiles, birds, mammals

II. Animal Terminology:

Draw an organism with …

Asymmetry:

Radial:

Bilateral:

A. **Symmetry** = whether one half of the animal matches the other half

1. **Asymmetry** – does NOT match (sponge)
2. **Radial** – matches many ways (jellyfish)
3. **Bilateral** – matches one way (left-hand side and right-hand side)

B. **Segmentation** – division of some animals into repeated parts, some of which may be used for different functions (ex. earthworm)

C. **Cephalization** – concentration of sense organs in a head region

Check Yourself!

1. What are the two main groups of animals?

2. What is the purpose of segmentation in some animals?

III. Life Functions (STERNGRR)

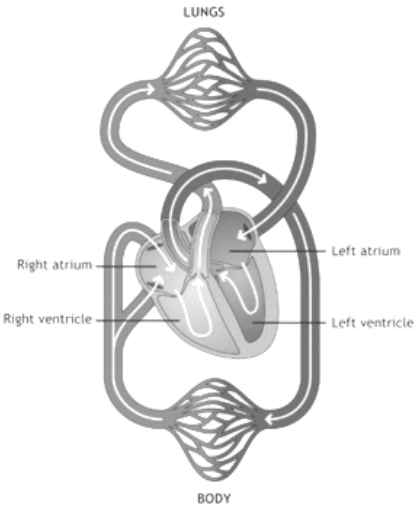
A. Synthesis – how organisms build necessary molecules

1. Protein synthesis – ribosomes in the cells of animals are used to make proteins from amino acids based on DNA code. The proteins are used for structures such as muscle fiber, enzymes, antibodies, and pigments.
2. Lipid synthesis – the ER in the eukaryotic cells of animals produces lipids such as phospholipids needed for the cell membrane

B. Transport – how organisms get what they need to cells; how they move waste from cells to organs of excretion

1. Blood cells carry nutrients and oxygen to the cells of an animal, and carry waste products away from those cells.
2. In animals with a **closed circulatory system** blood is enclosed in vessels such as arteries and veins. In animals with an **open circulatory system**, the blood flows freely in a body cavity where it makes direct contact with internal organs.
3. Some animals have a heart to pump blood throughout the body. The **four-chambered heart** of mammals is designed to separate oxygenated and deoxygenated blood as it passes through two circuits. The pulmonary circuit takes deoxygenated blood to the lungs where it picks up oxygen and releases carbon dioxide. The systemic circuit takes the oxygenated blood to the body cells.

On the diagram, shade the oxygenated blood red and the deoxygenated blood blue:



C. Excretion – how organisms get rid of their waste and balance their fluids (pH, salt concentration, water). Excretory structures help animals to perform these functions.

Identify 3 specialized excretory structures:
1.

2.

3.

1. Invertebrate animals may have specialized excretory structures in some body segments to filter nitrogenous waste from the blood. Examples include **nephridia** in annelids and **Malpighian tubules** in insects.
2. Vertebrate animals use organs called **kidneys** that are made up of smaller parts called **nephrons** to filter wastes from the blood. This waste, called urine, passes to tubes called ureters and then exits the body through an opening.

D. Respiration – how organisms get oxygen from the environment and release carbon dioxide back to the environment

Draw a picture showing gases moving across a membrane, such as skin. Label the direction of each gas using arrows:

1. In some animals such as worms, oxygen is able to diffuse through moist skin and enter the bloodstream.
2. Other invertebrate animals such as insects may have specialized structures in certain body segments to take in oxygen. Examples include tiny pores called **spiracles** in insects.
3. Aquatic invertebrates and vertebrates rely on **gills** – thin membranes that allow the diffusion of oxygen from the water into the bloodstream.
4. Terrestrial vertebrates rely on well developed **lungs** with numerous **alveoli** (small clusters that are one-cell thick and allow for fast diffusion of oxygen into blood and carbon dioxide out of blood).

E. Nutrition – how organisms break down and absorb food

1. Animals have a variety of different ways to obtain food from their environment and begin the process of digestion. Insects may have chewing mouthparts called **mandibles**, while many vertebrates have teeth that are specialized for their food sources.

What does absorption mean?

What structure is most important for absorption?

2. The digestive tract of many animals includes an **esophagus**, a **stomach** that contains digestive enzymes to break down the food chemically, and **intestines** for absorption. The intestine is divided into the small intestine (absorption of nutrients) and the large intestine (absorption of water). The lining of the intestine contains finger-like projections called **microvilli** to increase the surface area and allow for more efficient absorption. Accessory organs such as the liver and pancreas produce and secrete digestive chemicals.

Check Yourself!

1. What types of molecules do all animals have to synthesize?
2. What is the basic purpose of transport?
3. What is the function of the 4 chambered heart?
4. How do kidneys aid excretion?
5. What structures that make up the lung allow for more efficient gas exchange?
6. What is the purposed of microvilli in the small intestine?

F. Reproduction – sexual verses asexual, types of fertilization

1. Some simple animals have the ability to reproduce asexually. For example, **fragmentation** may occur in sponges, and starfish have the ability to **regenerate** lost parts.
2. Sexual reproduction in animals requires the male sperm to fertilize the female egg.
   a. Animals that live in or around water may utilize **external fertilization**. Females lay eggs and males later fertilize them outside of the female's body.
   b. Most land animals utilize **internal fertilization**. The male places the sperm inside the female's body.

External fertilization requires animals to live near _____, while internal fertilization is an adaptation for life on _____.

3. Most animals have either male or female reproductive organs. However, some animals are **hermaphrodites**, and have both male and female reproductive organs and therefore produce both sperm and egg.

G. Growth and development – metamorphosis, development in egg or in uterus

1. Many animals develop from eggs

Draw and label complete metamophosis for an insect <u>or</u> for an amphibian:

a. Insects and amphibians develop from eggs, and then undergo **metamorphosis** (body changes during life span).
   i. **Incomplete metamorphosis**: egg→ nymph (small adult-like body) → molts exoskeleton → adult
   ii. **Complete metamorphosis**: egg→ larva→ pupa→ adult

b. Reptiles, birds and mammals called monotremes lay **amniotic eggs.** This creates a protective environment for the embryo where it can develop on land without drying out. The amniotic egg contains yolk, providing a food source for the developing embryo, as well as membranes for gas exchange and the storage of waste.

2. Mammals called marsupials are born very immature and continue their development in a pouch on the mother's body.
3. Most mammals develop in the uterus of the mother. The placenta connects the embryo/fetus to the mother's circulatory system while the embryo/fetus develops internally.

H. Regulation – control the body's responses by responding to stimuli and maintains homeostasis

Draw a neuron:

1. The basic unit of the nervous system is a nerve cell called a **neuron**. Neurons are shaped according to their function of sending and receiving messages.

Name the 2 body systems that are most responsible for "regulation" in animals.

1.

2.

a. Simple animals such as worms may only have clusters of nerve cells that allow them to respond to stimuli
b. Animals such as insects and all vertebrates have complex sensory structures that all them to respond to stimuli.
c. Higher animals have a complex nervous system including a brain.

2. Many animals use **hormones** (part of the endocrine system) to respond to some stimuli and to regulate body systems. Hormones travel through the circulatory system as a form of long distance communication between the cells of an organism.

Check Yourself!

1. What is a hermaphrodite?

2. What are the three types of mammalian embryo development?

3. What is metamorphosis?

4. What is the role of the nervous system?

IV. Animal Behavior

Give any example of a stimulus and a response:

A. A behavior is anything an organism does in response to a stimulus in its environment. A **stimulus** is any kind of signal (chemical or physical) that can be detected by an organism; a **response** is the organism's reaction to the stimulus

Ex. Lowered blood sugar causes a release in insulin which triggers a feeling of hunger

B. Behaviors have evolved as a result of natural selection

1. A behavior that is beneficial to an organism has **adaptive value** allowing the organism to survive and reproduce better that those organism's that do NOT display this behavior

Don't forget! Behaviors occurring as a result of genes and the environment illustrates the concept of _____ vs. _____

2. These behaviors may be directed by genes (DNA) and can therefore be inherited by organisms from their parents
3. Most behaviors occur as a result of inherited genes AND environmental influences

C. There are two main types of behavior
   1. **Innate behaviors** are inborn (genetically programmed), so the organism is born already "knowing" the behavior
   2. **Learned behaviors** are acquired during an organism's life and may change with practice and experience

Check Yourself!

1. What is a behavior?
2. What are the two main types of behaviors?
3. What is adaptive value?
4. Circle the stimulus and put a square around the response:
   a. The skin itches and the dog scratches.
   b. Chimpanzees bare their teeth at the approach of a baboon.

V. Innate behaviors

A. Simple innate behaviors:
   1. **Automatic** – quick, unconscious reactions
      Ex. **Reflexes** such as blinking
   2. **Fight-or-Flight response** – the body prepares for action in response to stress or fear
      Ex. Increased heart rate when in a car accident

B. More complex innate behaviors (and urges) are often referred to as **INSTINCTS**. Simple instincts include "**suckling**", allowing animals to be able to feed right after birth. Other instincts are more complex; these behaviors may be classified as one of the following:
   1. **Courtship behavior** – pre-mating behavior designed to help an organism recognize and pick the "best" mate
      Ex. Fireflies flash lights

Watch It!

Innate behavior summary:

1. Simple
a.

b.

2. Instincts
a.

b.

c.

d.

e.

2. **Territoriality** – defending physical space against other animals; reduces competition for scarce resources .
   Ex. A cat scent-marks its territory to warn others
3. **Aggression** – a threatening behavior that one animals uses to gain control over another
   Ex. Lions show their fangs and snap at other lions
4. **Dominance Hierarchy** – a social ranking within a group that establishes dominant and submissive members
   Ex. A puppy rolls over and exposes its belly to adult dogs
5. **Orientation behaviors**: Animals display **TAXIS** behaviors – movement toward or away from a stimulus
   a. **Phototaxis** - movement in response to light
      Ex. Moths are attracted to light (positive)
   b. **Chemotaxis** – movement in response to chemicals
      Ex. Insects are attracted to chemical signals from other insects (positive)

C. Behavioral Cycles (**Biological "Clock"**)

1. Many animals respond to periodic changes in the environment with daily or seasonal cycles of behavior; these cycles allow for survival during periods when food or other resources may not be available
2. **Circadian rhythms** are daily cycles of behavior
   Ex. sleeping and waking
3. **Seasonal rhythms** occur at certain times of the year
   a. **Migration** – movement from one place to another and back again in response to environmental stimuli
   b. **Hibernation** - a decrease in metabolism in response to colder temperatures
   c. **Estivation** - a decrease in metabolism in response to warmer temperature

Give 4 examples of "biological clocks":
1.

2.

3.

4.

Check Yourself!

1. Name two simple innate behaviors.
2. More complex innate behaviors are called _____.
3. Define a taxis behavior.
4. What is a "biological clock"?

VI. Learned Behaviors

A. Learned behaviors are present mostly in animals with a more highly developed nervous system

B. Learning requires **motivation** – an internal need that causes an animal to act (ie. hunger).

C. Types of learning:

1. **Habituation** – occurs when an animal is repeatedly given a stimulus with no punishment or reward; eventually the animal stops responding

   Ex. You are able to sleep through the night even though you live close to the train tracks

2. **Classical Conditioning** – occurs when an animal makes a connection between a stimulus and some kind of reward or punishment; also called "**learning by association**"

   Ex. **Pavlov's dogs**

   Pavlov showed the dogs food. The dogs salivated. Pavlov started to ring a bell every time he fed the dogs. Eventually, the dogs would salivate whenever they heard the bell – even when food was not present.

3. **Operant Conditioning** – occurs when an animal learns to behave a certain way through repeated practice, in order to receive a reward or avoid punishment; also called "**trial-and-error**"

Types of learned behaviors:

1.

2.

3.

4.

Watch It!

Ex. A mouse learns how to get through a maze in order to get the food at the end

4. **Insight Learning / Reasoning** – the most complicated form of learning that occurs when an animal applies something it has already learned to a new situation

Ex. A pianist is able to play a new piece of music by "ear"

Check Yourself!

1. What is motivation?

2. What is the difference between classical and operant conditiong?

3. Who was Ivan Pavlov?

VII. Combining Innate and Learned Behaviors – Most behaviors result from a combination of innate and learned behaviors

A. **Social Behaviors** – often combine learned and innate behaviors

1. Whenever animals interact with members of their own species, they are exhibiting social behaviors
2. Some animals may form **societies** – a group of related animals of the same species that interact closely and often cooperate with one another. Membership in a society may offer great survival advantages

Ex. Zebras herd when grazing to confuse predators

3. Social behaviors include courtship, territoriality, dominance hierarchy, and communication.

Examples of social behaviors (indicate if innate or learned):

1.

2.

3.

4.

B. **Imprinting** involves very young animals recognizing and following the first moving object they see – the urge to follow is innate but must learn from experience what object to follow

Ex. Ducklings imprint on their mother

C. **Communication** involves the passing of information from one organism to another

1. Innate forms of communication may involve sound (a whale's song), sight (baring teeth), touch (chimp grooming), or chemicals (insects release **pheromones**).
2. The most complex form of communication is language – the use of symbols to represent ideas; requires a complex nervous system, memory, and insight

Pheromones are….

Example:

Check Yourself!

1. What is a society?

2. Name an animal that is likely to imprint on the first moving object it sees.

3. How are pheromones a means of communication?

4. What is the most complex form of communication?

Concept Map: Types of Behavior

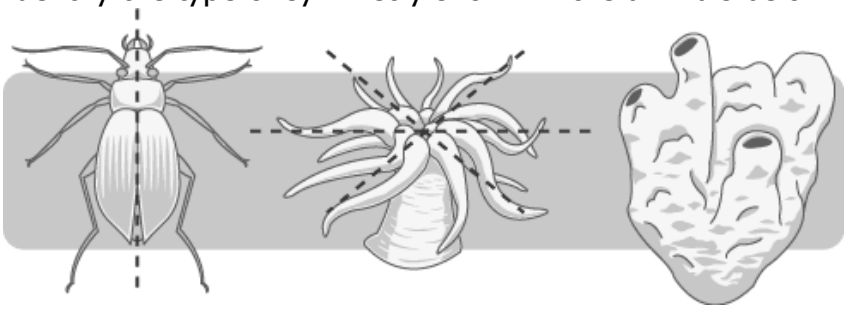
Innate		**Learned**
_____ / Genetic Instinctive Examples: _____ Fight-or Flight _____ Territoriality Aggression _____ _____ Taxis Biological Rhythms	Response to _____ Result of Natural Selection	_____ Require <u>Motivation</u> Examples: Habituation _____ _____ Operant Conditioning Insight / Reasoning

Word Bank:

Acquired	Inborn
Classical Conditioning	Motivation
Courtship	Reflexes
Dominance Heirarchy	Stimulus

Unit 5 / Module 14
Problem-Solving Set

1. Identify the type of symmetry shown in the animals below:



_____ _____ _____

2. For each life process named, explain one adaptation that would allow organisms to live on land:

Life process	**Adaptation for life on land**
Respiration	
Reproduction	
Growth and Development	

3. Identify the 3 body systems that are MOST responsible for regulating body systems and maintaining homeostasis:
   a.
   b.
   c.

4. Identify each statement as pertaining to innate (I) or learned (L) behavior. Label (B) if the statement applies to both.

_____ Born knowing the behavior	_____ Requires a teacher
_____ Result of natural selection	_____ Controlled by genes
_____ Inherited from parents	_____ Requires practice
_____ Allows for adaptation and change	_____ Includes instincts
_____ Animals with short life spans	_____ Includes reflexes

5. Have you ever noticed that dogs and cats scratch the dirt or litter to cover up their urine and feces? This is an instinctive behavior. What do you think is the survival advantage for this behavior?

6. Complete the chart by identifying the type of **INNATE** behavior described:

Description	**Type of Behavior**
Mosquitoes are attracted to human flesh due to the detection of body heat.	
Monarch butterflies winter in Mexico, then travel North toward Canada in spring.	
Male spiders present the female with a "gift" of an insect.	
Desert toads burrow underground during the dry season.	
A lion bares his teeth and snaps at other lions while feeding.	
Horses in a pasture line up to come in for feeding in the same sequence each night.	
Racoons are most active in the hours between dusk and dawn.	
A male sea lion patrols his area of the beach and chases away other males.	

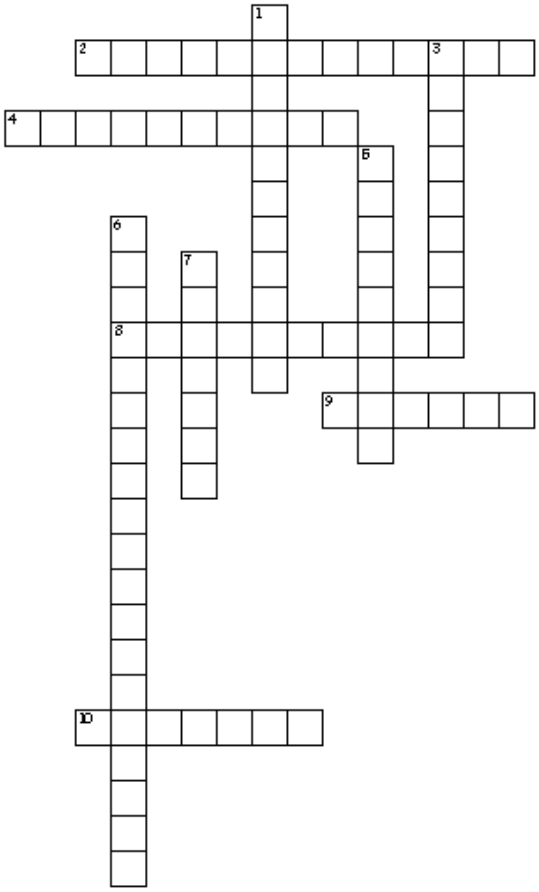
7. Social behaviors are those behaviors that allow individuals to function better in a group or society. Read the descriptions, and then identify the type of social behavior.
    a. Helps an individual to find a mate in the society _____
    b. Minimizes competition by allowing certain individuals in the society first access to food and other resources _____
    c. Ensures that an individual has access to enough food and other resources in a given space _____

8. Observe the following picture:

    a. The type of behavior shown is called _____.
    b. Explain how this type of behavior is a combination of innate and learned.
    _____
    _____
    _____
    _____

9. Complete the crossword on learned behavior:

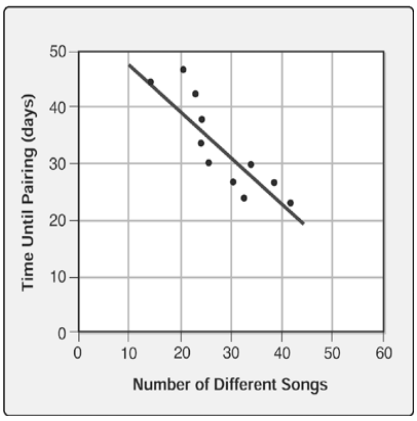
Learned Behavior



Across
2. Another term for operant conditioning
4. Internal need that causes learning to occur
8. Habituation causes an animal to stop _____ to a stimulus
9. Scientist who experimented with dogs to show classical conditioning
10. Learned behaviors occur in animals with more _____ nervous systems

Down
1. Type of behavior; Ex. After a few weeks, sirens from a nearby fire station stop waking you at night
3. Another term for insight learning
5. Type of conditioning that is shown by a cat running to the kitchen when he hears the can opener
6. Type of behavior; Ex. Chimpanzees try various objects to extract termites from a mound
7. Most complex type of learning

10. A researcher observed sedge warblers during breeding season. She charted the number of different songs a male bird sang compared to the time it took him to pair with a mate. The graph shows her data.



a. As the number of different songs increases, the time until pairing _____.
b. What type of innate behavior is this data associated with? _____.
c. Explain how bird songs are a combination of innate and learned behavior.

11. Read the passage below, then complete the chart:

> Many different animals display social behaviors. Honeybees, schooling fish, and herding mammals are some that form social groups. In a honeybee colony, there is division of labor in the group, allowing many tasks to be accomplished for the good of the group. Schooling fish and herding mammals form loose associations that allow for mutual protection from predators and increased opportunities to find a mate. However, in these large groups there is more competition for resources among group members. Another problem with large groups is that the spread of contagious diseases may be increased if one member becomes infected. Some mammals, such as chimpanzees have evolved very complex social structures that are organized in dominance hierarchies. This type of social structure offers a very rich learning environment for the young.

Advantages of Social Behaviors	**Disadvantages of Social Behaviors**
1.	1.
2.	2.
3.	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

12. Honeybee Society:

Queen	The only reproductive member of the hive – lays eggs
Workers: 30,000-60,000 sterile female bees that have various jobs	
Tend Queen	Bring food to queen, groom queen
Foragers	Bring pollen and nectar to the hive
Undertakers	Carry out dead bees
Nurses	Care for brood (developing eggs)
Groomers	Clean other worker bees
Guards	Guard entrance to hive
Honey makers	Make honey out of pollen and nectar
Drones	The only males in the hive (5-12); only job is to fertilize queen

Honeybee communication: all information is transferred by **touch**

- "Waggle dance" – Tells direction and distance to food source
- "Grooming dance" – Bee shakes to attract a groomer

a. Which type of behavior are bees using when they perform the waggle dance?

b. What method of communication do honeybees use?

c. Could a single worker bee leave the hive and start her own colony? Explain.

d. How does the social structure of these insects benefit the species?

Image credits:
http://www.drawingcoach.com puzzlemaker.school.discovery.com www.phschool.com
http://evolution.berkeley.edu/evolibrary/images/symmetrydiagram.gif

Unit 6: Ecosystems

Module 15: Ecological Principles

NC Essential Standard:
- 2.1 Analyze the interdependence of living organisms within their environments

STOP!

True or False …What do you think?

1. A species high on the food chain is a predator to everything below it.
2. Energy accumulates in an ecosystem so that a top predator has all of the energy from everything below it.
3. Changes in predator or prey populations will affect changes in the other.
4. If a population in a food web is disturbed, populations outside the linear sequence of that food chain will also be disturbed.
5. Competition always involves direct, aggressive interactions.
6. Plants compete for resources.
7. Members of the same species must compete for resources.
8. Populations exist in a state of either constant growth or constant decline.

I. What is the biosphere and how is it organized?

A. **Biosphere** – Area of the earth where life exists; extends from oceans depths to a few kilometers above land.

B. **Biomes** – An extensive area of similar climate and vegetation; there are six terrestrial biomes and three aquatic biomes.

C. **Ecosystem**

1. A physically distinct, self supporting unit of interacting organisms and their environment; Ex. Forest or pond
2. Four important processes:
   a. Production of energy (usually from sunlight)
   b. Energy transfer
   c. Decomposition
   d. Reuse of nutrients
3. Includes biotic and abiotic factors.
   a. **Biotic** – living things
   b. **Abiotic** – nonliving things
      Ex. Temperature, light, nutrients

Simple picture of an ecosystem (label a biotic and abiotic factor):

D. Communities and Populations

Simple picture of a community:

Simple picture of a population:

1. **Communities** – all the ecosystem's interacting biotic factors.
2. Communities may be broken down into smaller units called populations.
    a. **Populations** – A group of individuals that belong to the same species and occupy the same area and share common resources.
        i. Each population has a specific **niche**, which means total way of life.
        ii. The niche includes habitat, place in food web, competition,interrelationships, and resource needs (temperature, water)
    b. A community may have 1000's of populations (tropical rainforest) or relatively few (tundra)

Check Yourself!

1. List the levels of organization of the biosphere from highest level (biosphere) to the most specific level (niche).

2. What is the difference between an ecosystem and a community?

3. What four essential processes would be found in an ecosystem?
    a. c.
    b. d.

II. How is energy transferred in an ecosystem?

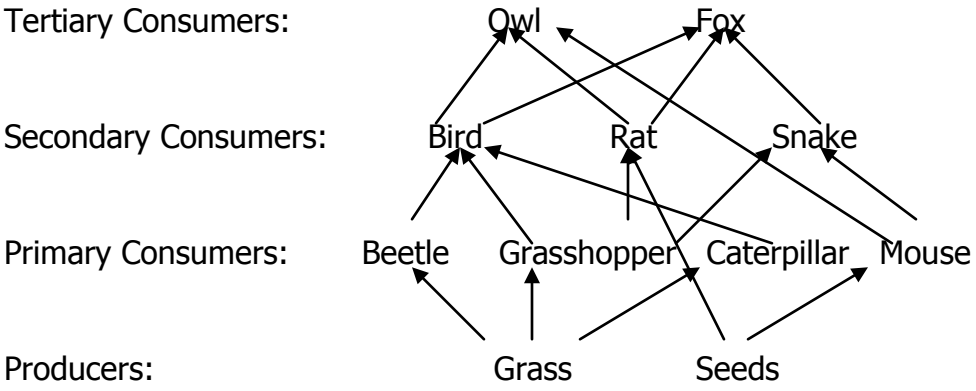
A. Trophic Levels

1. Organisms in a community survive by either producing or consuming food.

Answer using the food web:
1. **Organisms that eat grass.**
2. **Food sources for the fox.**
3. **An "omnivore".**
4. **An "herbivore".**
5. **A "carnivore".**

2. **Trophic levels** – levels of feeding in a community
   a. **Producers** – produce food for themselves (ex. plants). Other organisms may eat producers.
   b. Consumers – must take in food (ex. fungi)
      i. **Primary Consumers** – also called **herbivores** (ex. cow)
      ii. **Secondary and Tertiary Consumers** – may be **carnivores** (ex. lion) or **omnivores** (ex. bear)
      iii. **Decomposers** – break down wastes and dead organisms and return nutrients to the soil.

B. Food Webs
   1. Made up of overlapping food chains.
   2. Shows feeding connections; arrows illustrate energy transfer
   3. Ex.



C. Ecological Efficiency
   1. Producers have most available energy (sun).
   2. Energy is lost as it moves up through the food web; **10% rule** – only 10% of the available energy is passed to the next trophic level.
   3. The "lost" energy is used to catch, eat, and digest food.

10% Rule:
Carnivores (_____ cal)
↑
Herbivores (_____ cal)
↑
Plants (1000 cal)

Check Yourself!

1. What is a trophic level?

2. What is the difference between an omnivore and a carnivore?

3. From the food web above, write out a food chain that includes the rat.

4. Which level in a food web has the most energy?

III. How is matter reused in an ecosystem?

A. Role of Decomposers

1. **Decomposers** break down wastes and dead organisms
2. Decomposition allows nutrients to be returned to the soil and atmosphere; this allows nutrients to be reused.
3. Decomposers include fungi, bacteria, and invertebrates.

B. **Biogeochemical Cycles** – the pathway through which a substance is recycled.

Diagram of water cycle:

1. Water Cycle

a. Enters ecosystem by **precipitation**; may **infiltrate** the soil (be absorbed) or **run-off** into surface water.

b. Returned to atmosphere by **evaporation** or **transpiration** (the loss of water by plants)

2. Carbon Cycle

a. Powered by two main processes

i. **Photosynthesis** – plants and algae capture CO_2 from the air and change it into sugar (which have carbon)

ii. **Respiration** – all living things break down sugars for energy, which returns CO_2 to the atmosphere

Factors that ADD carbon to atmosphere:

Factors that REMOVE carbon from atmosphere:

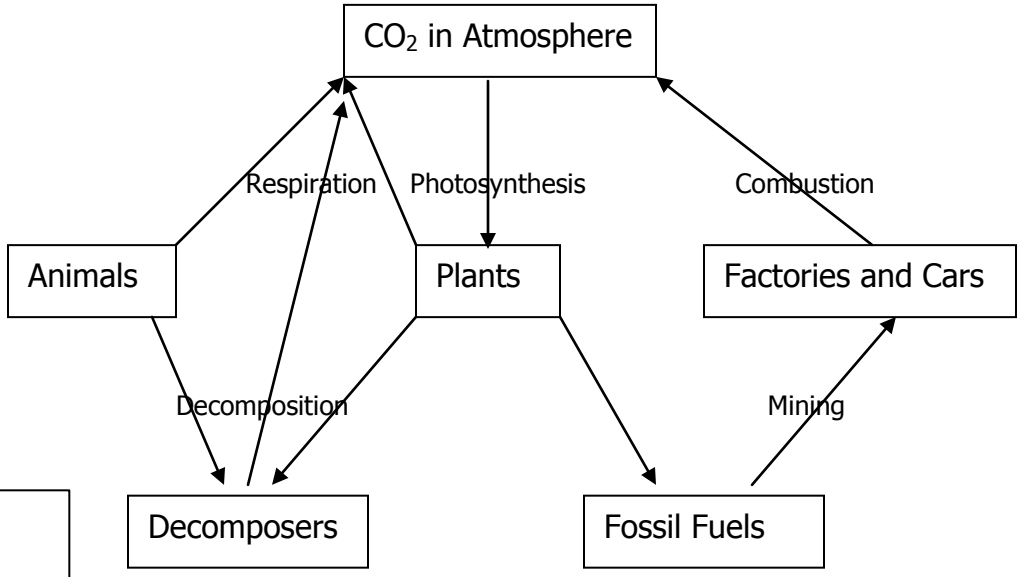
b. Other factors in the carbon cycle:

i. Decomposition returns carbon to the soil and atmosphere.

ii. Humans burn fossil fuels which adds CO_2 to the atmosphere and contributes to climate change.

iii. Deforestation removes trees which normally photosynthesize and remove CO_2 from atmosphere.

Diagram of Carbon Cycle



Watch It!

3. Nitrogen Cycle

a. Nitrogen is essential for living organisms so that they can build proteins; nitrogen is plentiful in the atmosphere, but is not usable in this form.

b. **Nitrogen fixation** – bacteria living in the root nodules of bean plants (legumes) convert nitrogen from the air into a more usable form.

c. Nitrogen fixation is the first of many steps that involves bacteria and changing the form of nitrogen.

Check Yourself!

1. How do decomposers help with the recycling of nutrients?

2. How do plants return water to the atmosphere?

3. What two processes drive the carbon cycle?

4. What organisms are essential for the conversion of nitrogen?

IV. How do living things interact in a community?

A. **Competition** – a struggle for resources among organisms.
   Ex. nesting space for birds

Picture of competition:

B. **Predation**
   1. **Predators** are organisms that consume other organisms.
      Ex. Zebra eating grass
   2. **Prey** are the organisms that are consumed.
      Ex. Earthworm being eaten by bird

C. **Symbiosis** – two organisms of different species living together in a close, permanent relationship
   1. **Mutualism** – the two organisms benefit each other
      Ex. Termite and protozoan
      Ex. Lichen – an alga and a fungus
   2. **Parasitism** – one organism benefits; the other is harmed
      Ex. Tapeworm and human
      Ex. Mistletoe and tree
   3. **Commensalism –** one organism benefits; the other is not benefitted or harmed
      Ex. Epiphytes growing on trees
      Ex. Barnacles and whales

Fill in the correct type of symbiosis for the following symbols:

+, + _____

+, - _____

+, 0 _____

Check Yourself!

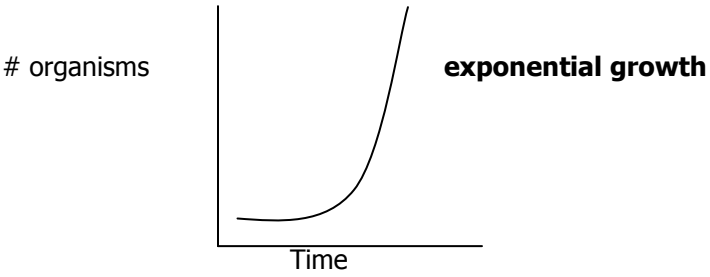
1. Which biotic relationship is defined as a "struggle for resources"?
2. In your backyard, you observe a snake entering your bird feeder. Who is the predator and who is the prey?
2. What is symbiosis?

V. How do communities change over time?

A. Population growth

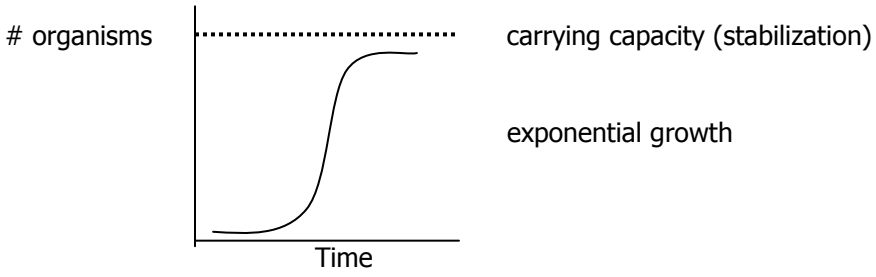
1. Populations will grow until they reach their **biotic potential**, unless they are limited by factors in the environment; this type of growth is known as a **J-curve**

Define "exponential growth":



2. **Limiting factors**, such as availability of food, water, and space establish a carrying capacity for populations; this type of growth is known as an **S-curve**;

List limiting factors for a population of dandelions:



3. **Carrying capacity** is defined as the number of individuals an environment can support. Limiting factors in the environment help to maintain ecosystem stability by allowing populations to fluctuate around the carrying capacity. This is called **dynamic equilibrium**.

a. **Density dependent factors** have a greater effect on a population when there is a higher population density (the number of individuals in a given space). For example, competition, predation, and the spread of infectious disease are density-dependent factors.

b. **Density independent factors** influence the size of a population regardless of its density. For example, natural disasters such as forest fires are density independent factors.

B. **Succession** is the idea that communities will replace other communities in a predictable, orderly way; this happens because every community alters the physical factors of the environment.

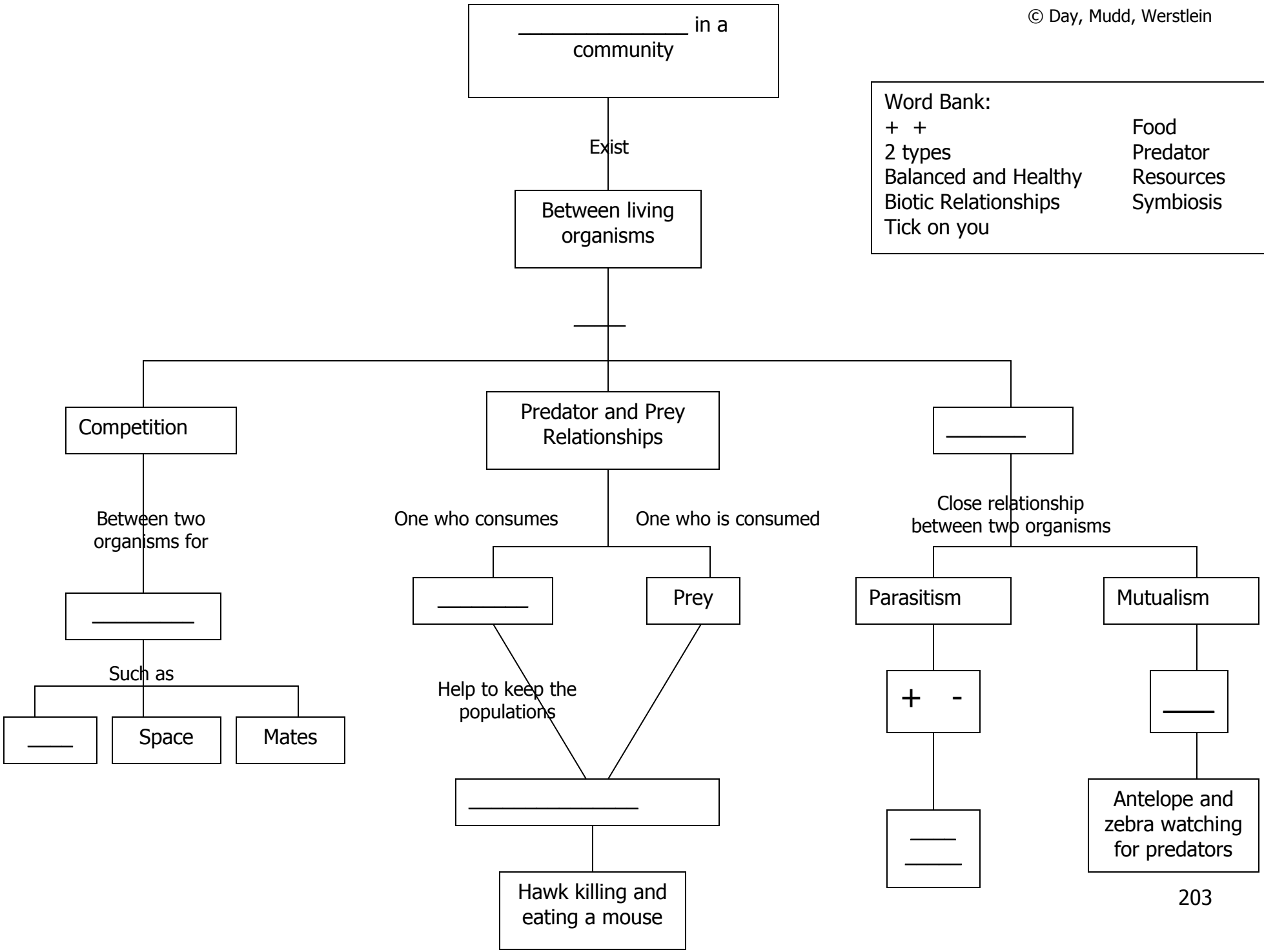
Ex. As trees grow, they produce shade

Check Yourself!

1. What kind of curve illustrates exponential growth?

2. What determines the carrying capacity of the environment?

3. List 3 examples of limiting factors.



Word Bank:

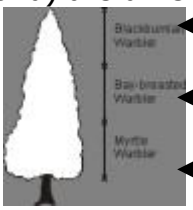
+ +	Food
2 types	Predator
Balanced and Healthy	Resources
Biotic Relationships	Symbiosis
Tick on you	

Unit 6 / Module 15
Problem-Solving Set

1. Put the following terms in order from <u>smallest</u> to <u>largest</u>:
   Biome Ecosystem Population Biosphere Community

   _____ _____ _____ _____ _____

2. Using the following picture, explain how the "niches" of various warblers (a type of bird) are different.



Explanation:

3. For each of the following, identify as a <u>biotic</u> or <u>abiotic</u> factor:

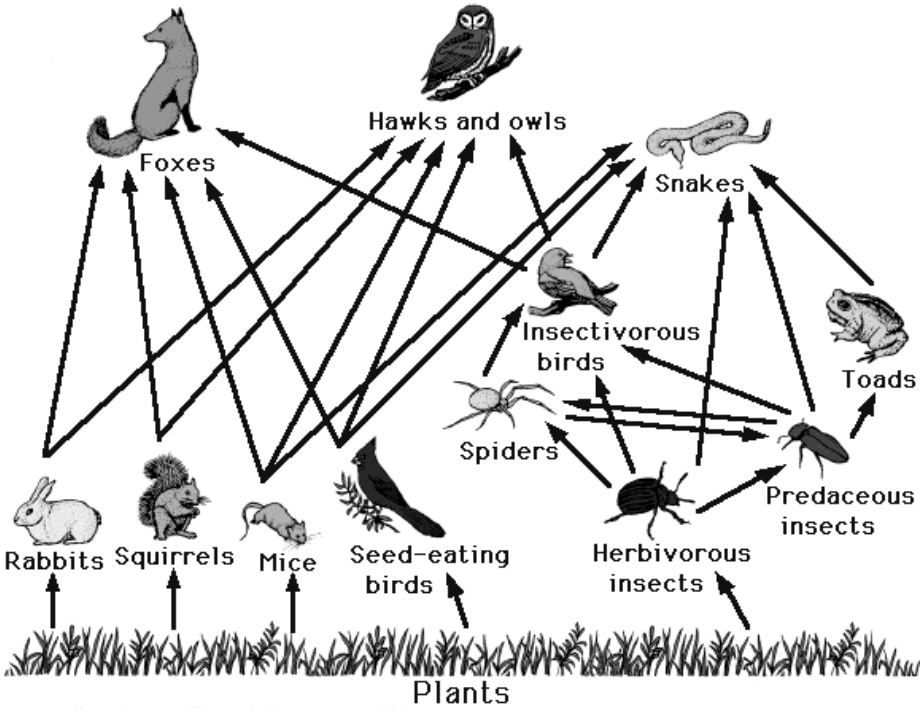
a. 
_____

b. 
_____

c. 
_____

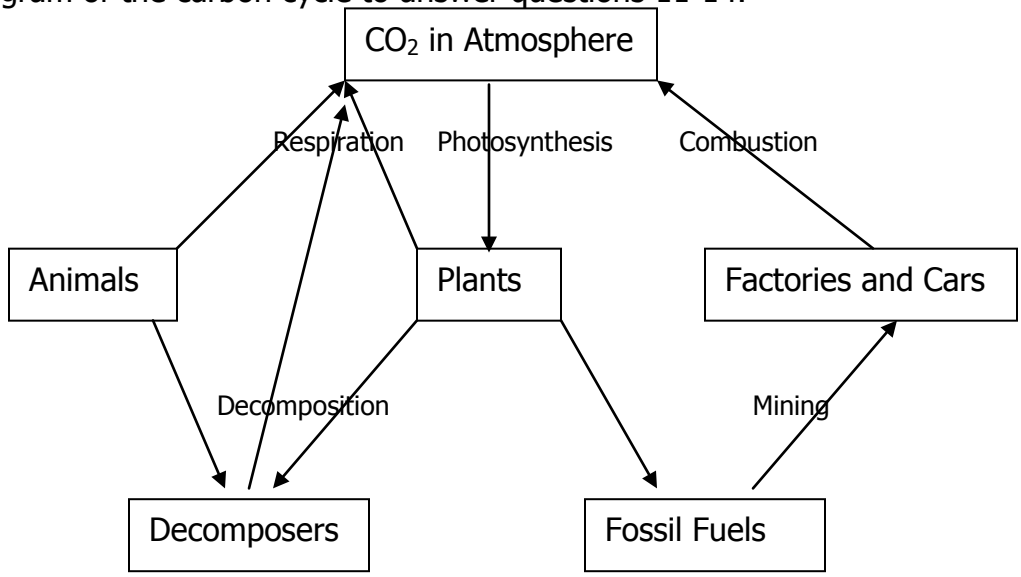
d. 
_____

Use the food web below to answer questions 4-10.



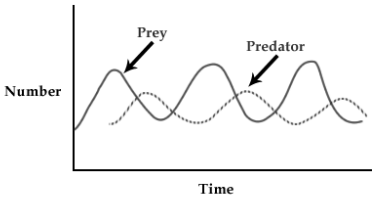
4. How many primary consumers/herbivores are there? _____
5. The fox can be a _____ or _____ consumer.
6. How many sources of food does the snake have? _____
7. The mice may be eaten by: _____, _____, or _____
8. The arrows show the direction of _____ flow.
9. In the food web, most of the energy is in the _____.
10. If there are 100 calories in a plant, _____ calories will be transferred to the rabbit and _____ calories will be transferred to the fox.

Use the diagram of the carbon cycle to answer questions 11-14.



11. What organisms take up carbon from the atmosphere? _____
12. These organisms use the process of_____ to convert carbon dioxide into sugars.
13. Name the 3 processes that can add carbon back to the atmosphere: _____, _____, _____
14. Humans are adding excessive amounts of carbon dioxide to the atmosphere because of our overuse of _____ _____.

15. Using the graph below, explain the relationship between predator and prey in a community:

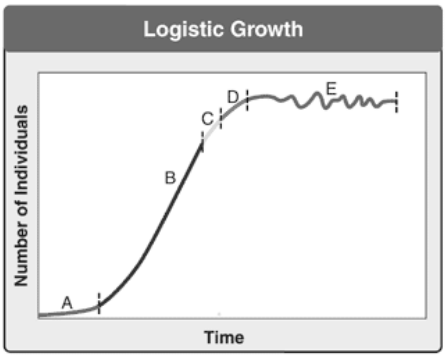


Explanation:

Fill in the chart below with the appropriate type of symbiosis:

Description	Type of Symbiosis
16. While bees gather nectar from flowers for food, they, in turn, pollinate other flowers.	
17. A vine winds up a tree in your yard so it can get closer to the sunlight. It does not block sunlight from reaching the tree.	
18. A tick attaches to your dog and sucks his blood.	
19. Remoras swim alongside sharks and eat the scraps of food the shark leaves behind.	
20. Oxpeckers ride on the backs of rhinos and pick insects and parasites off of the rhinos skin.	
21. A tapeworm enters a human as he eats undercooked meat, and attaches to the intestinal wall.	

Use the graph below to answer the following questions:



22. What type of population growth is shown in section "B"? _____
23. In section "E", stabilization has occurred because the _____ _____ has been reached.
24. This type of graph is also known as a(n) _____ - curve.
25. Assume that the graph above shows the population growth of bullfrogs in a local pond. List 3 limiting factors for the frog population. Be specific for frogs.

_____, _____, _____

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http://redcrossww.org/images/sunshine.jpg

Unit 6: Ecosystems

Module 16: Human Impact on the Environment

NC Essential Standard:
- 2.2 Understand the impact of human activities on the environment

True or False …What do you think?

1. Human population growth is only a problem in certain areas of the world.
2. Global climate change means the entire world and all areas are getting warmer for every season of the year.
3. Global warming is caused by a hole in the ozone layer.
4. Recycling means reprocessing returned products.
5. Acid precipitation is caused by gas pollutants released in the atmosphere.
6. Water pollution begins on land.
7. A non-native specie is a specie that is not typically found in a region.
8. Endangered species are no longer found on Earth.
9. When pesticides are used, the chemical remains in that area and specie.

STOP!

Sketch a graph of human population growth:

I. Why is human population growth an environmental problem?

A. Causes of human population growth

1. **Agricultural Revolution** – people settled into communities and more people were needed for division of labor; more reliable food supply can support a larger population.
2. **Industrial Revolution**–In the early 20th century technological advancements led to improvements in medicine and sanitation allowing for an increased birth rate and decreased death rate.
3. **Urbanization** (development of cities) leads to economic and social development, which influence human populations.

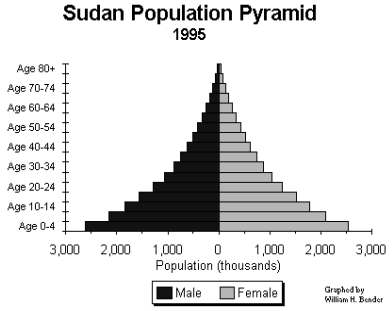
B. Effects of human population

1. Increased **pollution** – air, water, and land – ALL pollution problems relate back to overpopulation. Pollutants are produced as waste products from human activity, such as burning fossil fuels, mining, and use of consumer goods. Solid waste requires disposal in landfills or incineration.

2. Decreased **natural resources**, especially nonrenewable resources (available only in limited amounts).
   Ex. fossil fuels, minerals, metals
3. Increased land use – leads to loss of habitat for other species.

C. Census data – demographers construct **histograms** to use in predicting future population growth trends (field called "demography")

1. Developing and Growing (Ex. Sudan)



(from http://online.sd43.bc.ca)

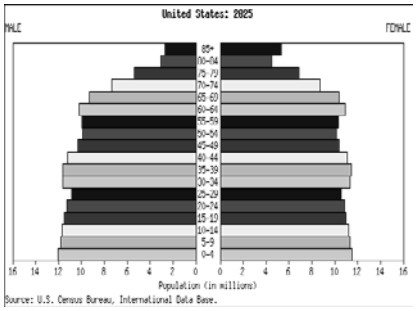
Draw the three basic shapes:

Increasing –

Stable –

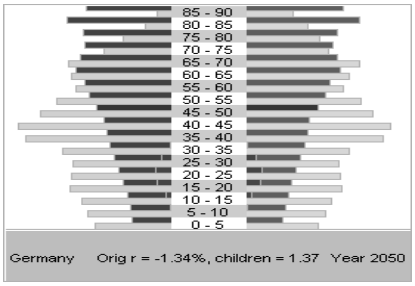
Decreasing –

2. Developed and Stable (Ex. United States)



(from www.mnforsustain.org)

3. Developed and Decreasing (Ex. Germany)



(from www.cbc.yale.edu)

D. Solutions

1. **ZPG** – zero population growth (birth rate = death rate).
   a. Limit number of births per family by offering tax incentives Ex. China
   b. Make birth control and family planning more available.
   c. Educate public and our political leaders.
2. **Conservation** – wise and careful use of resources through environmental **stewardship**
   a. Twenty percent of the world's population uses more than fifty percent of the world's resources.
   b. People in developed countries (like the U.S.) can decrease resource use by the 3 R's:
      i. **Reduce** – use less materials; for example, buying products that have less packaging
      ii. **Reuse** – use products more than once; for example, bring lunch in Tupperware instead of one-use containers
      iii. **Recycle** – return products to be re-processed; for example, old tires are used to make track surfaces
   c. **Sustainability** – ensuring the availability of resources and a stable environment for future generations.

Give an example of one human action that is NOT sustainable:

Check Yourself!

1. What were three causes of human population growth?

2. Why does human population growth lead to increased pollution?

3. How do people, particularly those in developed countries, need to lessen the impact of human population growth?

4. Why is the pyramid-shaped histogram characteristic of a growing population?

II. How is North Carolina affected by human activity?

A. Global Warming

1. Cause: Excessive **greenhouse gases** such as CO_2 and CH_4 in the atmosphere trap heat, leading to an abnormal increase in earth's surface temperature
   a. **CO_2** comes from burning fossil fuels in power plants, factories, and cars
   b. **CH_4** comes from bacteria in landfills and cow farts
2. Effects: With just a small increase in temperature such as 2-4 degrees Celsius, weather patterns will change worldwide. Polar ice caps may melt and **thermal expansion** occurs, flooding coastal cities and contaminating drinking water with saltwater.
3. Beach Erosion in North Carolina
   a. Sea level is directly related to global climate. In North Carolina, the sea level increase is twice the global average.
   b. Rising sea levels lead to beach erosion. Severe storms also increase erosion. The incidence of severe storms is increasing as a result of global climate change.
   c. Coastal residents attempt to prevent beach erosion to protect property, leading to negative environmental consequences to ocean ecosystems.

Global Warming:

Cause –

Effect –

NC Example –

B. Acid Precipitation

1. Cause: Harmful emissions from cars and factories, especially **nitrous oxide** and **sulfur oxide**, react with oxygen and water to make precipitation more acidic – with a pH less than 5.6
2. Effects: A lowered pH disrupts aquatic ecosystems, makes soil less fertile, harms plant life, and damages human property.
3. Acid Precipitation in North Carolina Mountains
   a. Red spruce and Frasier fir trees in the mountains are dying as a result of acid precipitation, damaging the ecosystem.

Acid Precipitation:

Cause –

Effect –

NC Example –

b. The mountains are greatly impacted by acid precipitation caused largely by pollutants from Tennessee. The soil has a low buffering capacity and acid fog continuously surrounds the trees making the damage more profound.

C. Water Pollution

1. Cause: Sources of water pollution often begin on land, such as oil from cars, sediments from naked land, and fertilizers from lawns. Other sources include illegal chemical dumping, acid rain, overheated water from power plants, and raw sewage.
2. Effects: A lack of clean drinking water is a leading cause of disease (such as cholera, dysentery, typhoid). Water pollution also affects many ecosystems through habitat destruction.
3. Waste Lagoons on North Carolina Hog Farms
   a. There are approximately 7 million hogs on industrial farms in NC, most in eastern NC which is a flood-prone coastal plain.
   b. Industrial farms raise thousands of animals in a small space, producing TONS of waste. The waste is stored in lagoons, but may run-off, leak or spill into surface water with rainfall.
   c. The sewage in the surface water leads to high levels of disease-causing bacteria such as E. coli, oxygen-depleting organic matter, and hormones/antibiotics used in feed
   d. Also, nitrogen run-off from the waste may contribute to outbreaks of **Pfisteria**, a single-celled alga that produces a deadly neurotoxin. Massive fish kills have resulted, along with health problems in fishermen and others exposed.

Water Quality:

Cause –

Effect –

NC Example –

Check Yourself!

1. What are the two main greenhouse gases?

2. What two pollutants are responsible for acid precipitation?

3. What part of the water cycle carries land pollution to the water?

III. How do humans negatively impact other species?

Word Help:
Bio –

Diversity -

A. **Biodiversity** – the number of different species of organisms that exist within an area and the genetic diversity within each species

B. Causes of Biodiversity Loss:

1. **Habitat Destruction** such as **deforestation**, fragmentation and pollution of aquatic ecosystems leads to loss of biodiversity. In NC, urban development in the Piedmont has led to biodiversity loss due to:
   a. Forests are **fragmented** – breaking up a large forested area into smaller zones due to construction.
   b. Clearing land for development leads to soil erosion which ultimately leads to water pollution.
   c. An increase in **impervious surfaces** such as asphalt and concrete lead to increased water run-off and pollution.
2. Introduction of non-native species, "**invasive species**"
   a. Kudzu, aka "The Vine That Ate The South"
      i. Kudzu vines are native to Japan. The vines were brought to the US during the Great Depression to plant in order to stabilize hillsides, minimizing erosion.
      ii. Kudzu vines have no natural predators in the US. The vines can grow up to 1 foot per day in our climate.
      iii. Excessive growth has engulfed forests, outcompeting native species for sunlight and soil nutrients, leading to loss of native biodiversity.
   b. Dutch Elm Disease
      i. Dutch Elm Disease is a fungus that spread to North America on crates made from Elm wood.
      ii. The disease easily spreads by insects or root to root
      iii. Dutch Elm Disease leads to the death of trees, impacting the environment and economy.

Loss of Biodiversity:

Cause –

Effect –

NC Example –

Accumulation	Magnification

3. Biomagnification of Pesticides
   a. **Bioaccumulation** is the build up of certain pesticides in the tissues of organisms (Ex. DDT in fish)
   b. **Biomagnification** is the increasing concentration as pesticides move up the food chain (Ex. DDT in bald eagles)

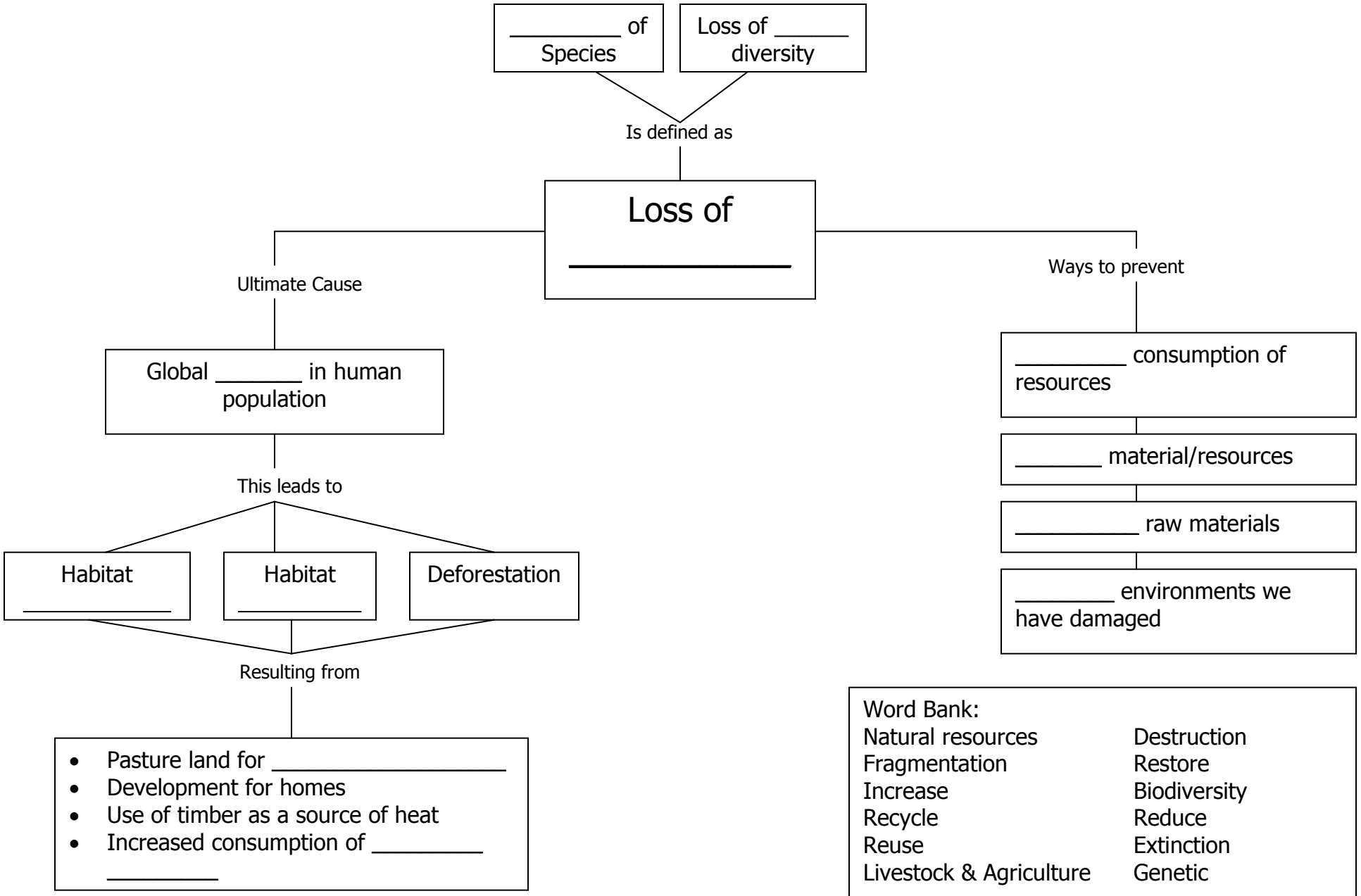
C. Effects of Biodiversity Loss:
   1. Endangerment/Extinction of Species
      a. **Endangered** species are at risk of becoming extinct. **Extinction** refers to the loss of a particular species.
      b. The Endangered Species Act provides protection for species recognized and listed by the government. This Act does not, however, provide adequate protection of the habitat.
   2. Loss of valuable medicinal or crop plants, and other species that may be potentially useful to humanity
   3. Lack of genetic variety makes crops more susceptible to disease, pests, and environmental changes

Watch It!

IV. What can you do to protect the environment?
   A. Awareness –each human impacts the environment, and because our population is large we have an ENORMOUS impact at the global level. "We cannot all do everything, but we can all do something."
   B. Specific suggestions:
      1. Reduce dependence on fossil fuels (Example – car pool, support "green power") and other nonrenewable resources
      2. Recycle whenever possible
      3. Limit use of toxic chemicals at home
      4. Consumer choices – support "green" businesses/products

Check Yourself!

1. What is biodiversity?
2. What is the difference between bioaccumulation and biomagnification?
3. What is a weakness of the Endangered Specie Act?



Word Bank:

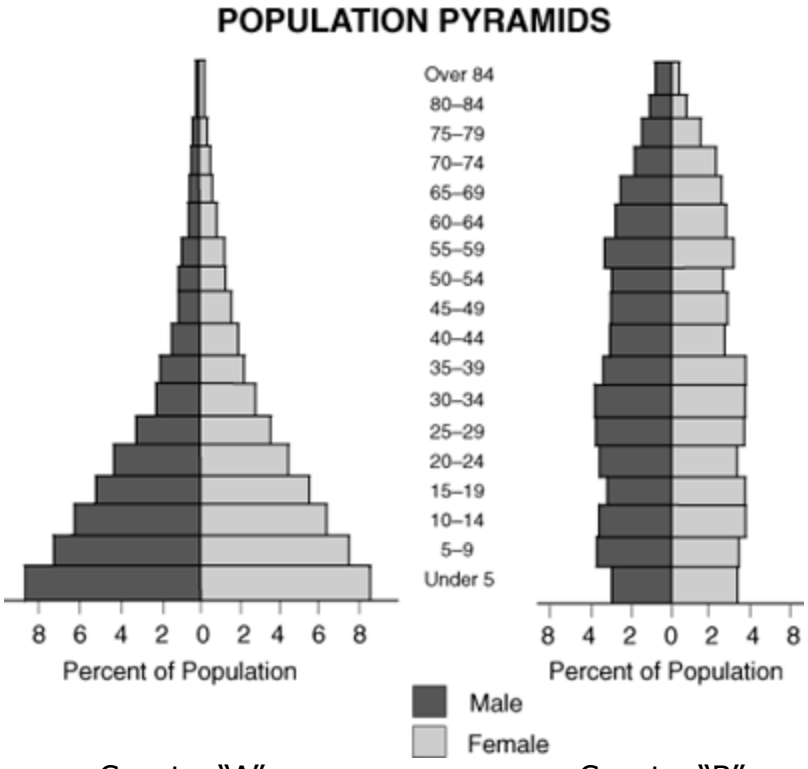
Natural resources	Destruction
Fragmentation	Restore
Increase	Biodiversity
Recycle	Reduce
Reuse	Extinction
Livestock & Agriculture	Genetic

Unit 6 / Module 16
Problem – Solving Set

1. For each of the following items, write an "I" if they increase with human population growth, or a "D" if they decrease with human population growth.

_____ fossil fuels	_____ landfills
_____ deforestation	_____ endangered species
_____ roads	_____ wilderness areas
_____ air pollution	_____ minerals/metals (mined from earth)
_____ water pollution	_____ biodiversity

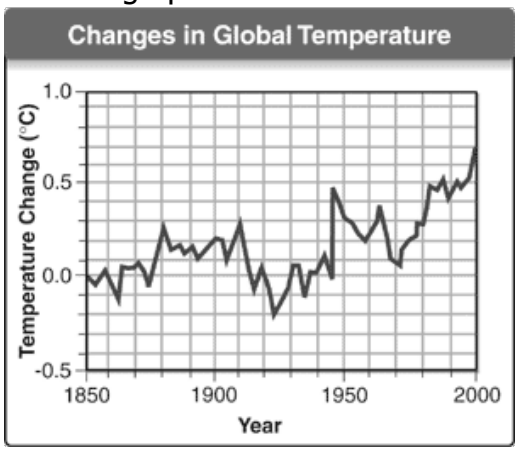
2. Use the population pyramids to answer the following questions:



Country "A" Country "B"

a. In Country "A", approximately what percentage of the population is under age 15? _____
b. In Country "B", approximately what percentage of the population is under age 15? _____
c. Which country is growing more rapidly? _____
d. Which country most resembles the United States? _____

3. Use the graph below to answer the following questions:

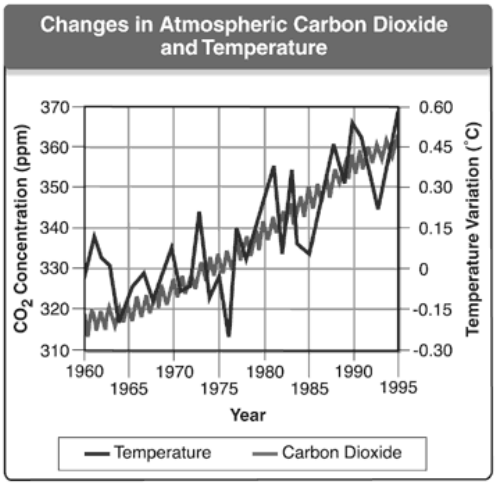


a. On the y-axis, what does 0.0 represent (Hint: this is where the graph starts, and the graph is measuring change)?

b. What was the overall temperature change between 1850 – 2000 (calculate the actual difference!)?

c. What trend does the data show between 1970 and 2000 (increase, decrease, staying the same)?

4. Use the graph below to answer the following questions:



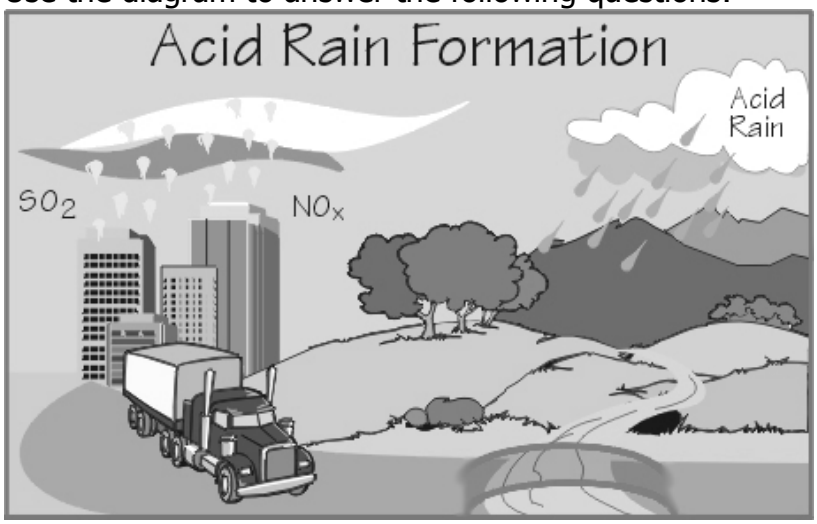
Note – the CO_2 line has smaller ups and downs (it shows uniform fluctuations).

a. What change/trend has occurred in CO_2 concentration since 1960?

b. Complete the following sentence:
As CO_2 concentration increases, temperature _____.

c. If CO_2 concentration continues to increase, what do you expect to happen to the temperature (infer from the trend shown in the graph)?

5. Use the diagram to answer the following questions:



a. According to the diagram, what are the two main pollutants responsible for acid rain?

b. Use the diagram to name two sources (things producing these pollutants) of these pollutants.

c. Name two ecosystems from the diagram that might be affected by acid rain.

6. For each of the global problems listed in the chart below, think of one local solution - something that **you** can do to lessen that problem.

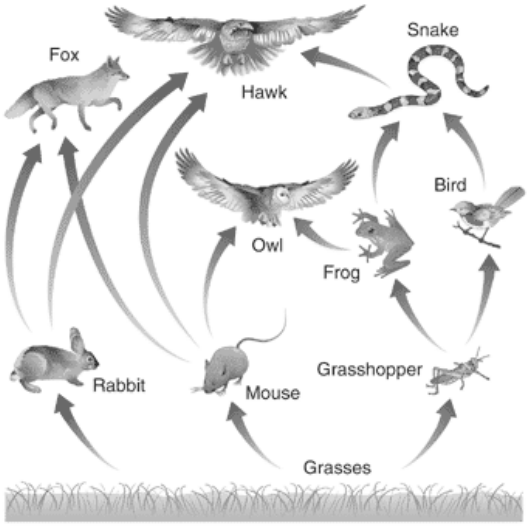
Global Problem	**Caused by**	**Local Solution**
Global Warming	CO_2 and CH_4	
Acid precipitation	SO_2 and NO_x	
Water Pollution	Run-off of land pollutants	

7. Read the passage, then complete the table below:

As the human population increases, there is an increasing need for more land to support this population. Forests are being cut down at an alarming rate to allow for development and agriculture. In the 1950's, approximately 14% of the Earth's land area was covered by rainforest, but today rainforest covers only about 6%. This relatively small percentage of Earth's land supports about 50% of Earth's species! Many of these species, such as the mountain gorilla, are now at risk. Another problem is habitat fragmentation. Giant pandas require quite a large land for each individual so that they will be able to get enough food to survive. Today, China's 1,100 giant pandas live in 24 isolated habitats that represent just a fragment of their historic range, because people require more land to support their own needs. Wetland destruction is another problem. Wetlands are drained or filled in so that people can live near lakes or seashores, but the organisms that depend on the wetlands have nowhere else to go. There has been a decline in migratory waterfowl populations, such as whooping crane as a result.

Name of Species	**Reason for Endangerment**

8. Answer the following questions about the food web below:



If a pesticide were sprayed on the grass…

a. Which organisms would be the first to experience bioaccumulation?

b. Which organisms would be most affected by biomagnification?

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