Name: _____ Period: _____

	Unit 5 - Energy Goals	I need help!		Still working…		Doing great!	
		1	2	3	4	5	6
1	I can explain the difference between products & reactants in a chemical equation.						
2	I can explain where all energy originates.						
3	I can explain which organelles in plants convert sunlight to energy.						
4	I can explain which gas is used by plants to start photosynthesis.						
5	I can explain which gas is released by plants during photosynthesis.						
6	I can list factors that influence the rate of photosynthesis.						
7	I can explain which organelles in animal cells convert plant energy.						
8	I can list the 5 basic steps of photosynthesis.						
9	I can explain the function of chlorophyll.						
10	I can explain which photosynthetic steps occur only in sunlight.						
11	I can explain which photosynthetic steps occur with & without sunlight.						
12	I can describe the products and reactants of the Calvin Cycle.						
13	I can write the equation for photosynthesis in words and the chemical equation						
14	I can explain where cellular respiration occurs						
15	I can explain what cellular respiration is.						
16	I can write the chemical equation for cellular respiration.						
17	I can explain what gas is used by eukaryotic cells for cell respiration.						
18	I can explain what gas is released by eukaryotic cells during cell respiration.						
19	I can explain what aerobic means.						
20	I can list the 3 steps of aerobic cellular respiration.						
21	I can describe where glycolosis occurs.						
22	I can list the products & reactants of glycolosis.						
23	I can describe where the Krebs Cycle occurs.						
24	I can list the products & reactants of the Krebs Cycle.						
25	I can explain where the electron transport chain gets the high energy electrons.						
26	I can explain the reactants & products of the electron chain.						
27	I can summarize the total products of aerobic respiration.						
28	I can explain what anaerobic means.						
29	I can list the 2 steps or anaerobic cellular respiration.						
30	I can describe the difference between lactic acid fermentation & alcoholic fermentation.						
31	I can summarize the total products of anaerobic cellular respiration.						
32	I can explain what is ATP.						
33	I can explain when organisms utilize ATP.						
34	I can explain how ATP is used and how it is changed.						
35	I can explain what producers are in an ecological pyramid.						
36	I can explain what primary consumers are in an ecological pyramid.						
37	I can explain what secondary consumers are in an ecological pyramid.						
38	I can explain what tertiary consumers are in an ecological pyramid.						

	Vocabulary Word	Definition in own words	Picture
1	Chloroplast		
2	Autotroph		
3	Heterotroph		
4	Chlorophyll		
5	ATP		
6	ADP		
7	Mitochondria		
8	Aerobic		
9	Anaerobic		
10	Pyruvic Acid (pyruvate)		
11	Glycolysis		
12	Kreb's Cycle		
13	Electron Transport Chain		
14	Lactic Acid Fermentation		
15	Alcoholic Fermentation		

DAILY ACTIVITIES

CHEMICAL REACTIONS

- A process that changes one set of _____ into another set of _____
- What starts the reaction is called the _____.
  - Will be located on the left side of the equation.
- What is produced in the reaction is called the _____.
  - Will be located on the right side of the equation.

Practice

$$H_2 + O_2 \rightarrow H_2O$$

What are the product(s) in this formula?

What are the reactant(s)?

PHOTOSYNTHESIS

Photo –
Synthesis–
To make food _____ light

Who does it?

- _____
- Algae (underwater plants)
- Cyanobacteria (photosynthetic bacteria)

Basic Photosynthesis
REACTANTS (Remember from Chemistry: what goes into reaction)

- _____ energy is absorbed
- Carbon dioxide and _____ are used

Formula for Photosynthesis:

Chemical formula:

In words:

Steps:

1) Plants _____ sunlight energy and _____ it to a usable form
2) Carbon dioxide enters plant _____ and water is taken in _____
3) _____ (_____) is used to make sugar molecules
4) Sugar is _____ (changed) to starch and stored
5) _____ is a bi-product (what is left over after the Rx)

Where does photosynthesis happen, in plants?

The organelle in which photosynthesis takes place is called the _____

Chloroplasts are _____ of chlorophyll (_____ →gives plants its color!)

- Stroma – area inside chloroplast that surrounds _____
- Thylakoid – flat sacs that are surrounded by _____
- Grana – Stacks of _____

Chlorophyll's job

- Collects _____ from the _____
- Plants use this energy to change _____ and _____ into food!

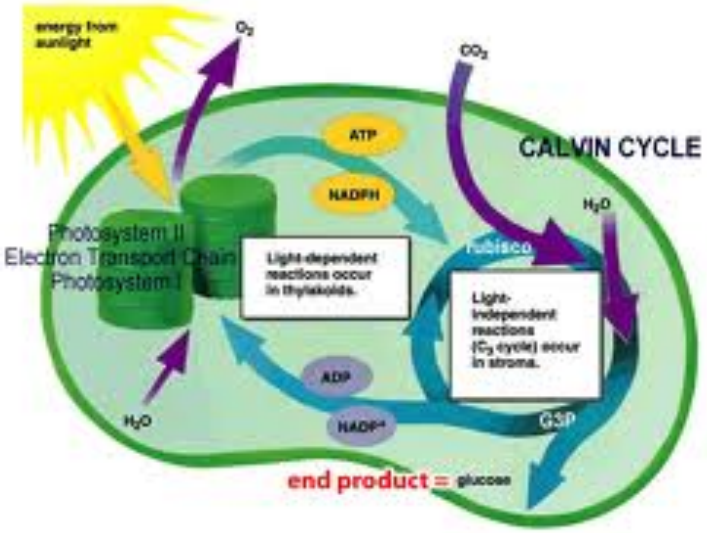
There are 5 basic steps to photosynthesis

A. Light Dependent Reactions
Happens: _____ in sunlight

1. _____ by chlorophyll molecules
2. Water is broken down
3. _____ is released
4. Generates molecules of _____

B. Light Independent Reactions
Happens: _____

1. _____ is broken down
2. _____ changes to _____ drives the *Calvin Cycle.*
3. Makes _____ (glucose, plant food)



Where do the reactants come from?

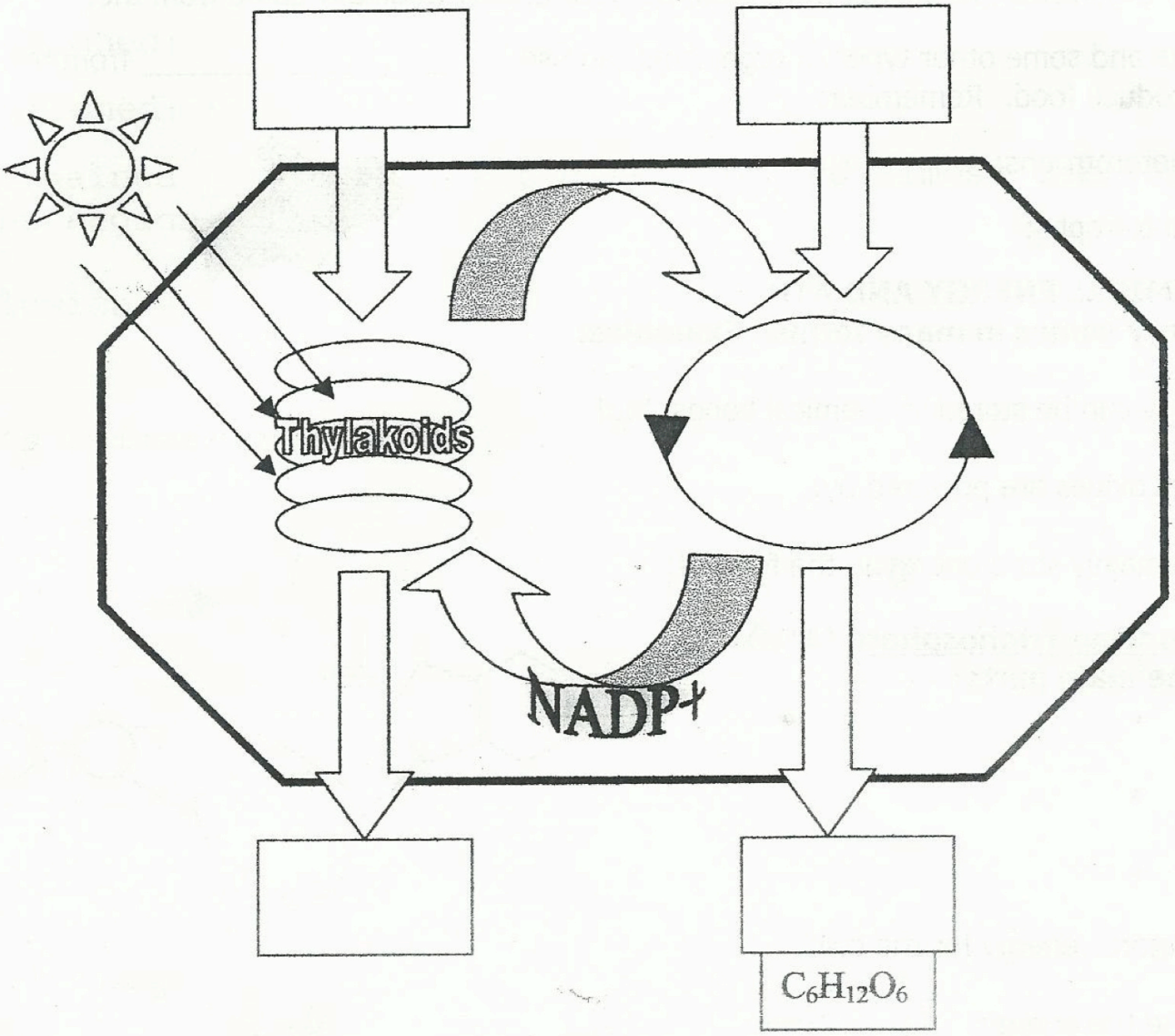
- _____ enters the plant from the roots
- It travels up tubes (straws) in the plant (_____)
- _____ _____ enters the plant through pores (holes) in the _____
- The pores are called stomata
- Why would a plant want it's pores closed?

Where do the products go?

- Oxygen is released back out of the _____
- Carbohydrates move through the plant in _____ called phloem
- They are stored as _____ or as _____ or cellulose
- They can be stored in the roots, the leaves or in the stems

BONUS: What is the name of the reaction that builds starch from many glucose molecules?

Chemical Reactions of Photosynthesis



1) What is USED in Light Reactions? _____
2) What part of this is given off as waste? _____
3) What is USED in the Calvin Cycle? _____
4) What is created from this? _____
5) What does NADP+ want to carry outside of the thylakoids? _____

FINAL QUESTION: Where will the products (#2 & #4) go to be used?

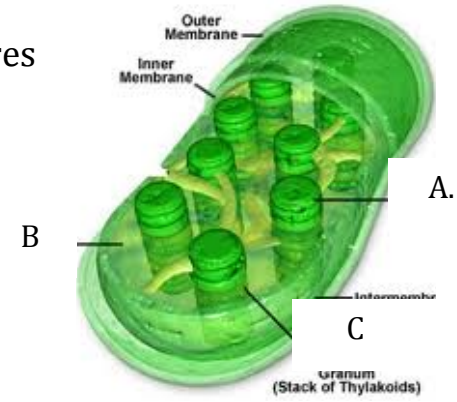
_____

What Do I Know So Far?
Photosynthesis

Complete this sheet thoroughly, checking yourself as you go along. Try to complete this sheet without your notes or book to show what you know so far.

Using the picture at the right, fill in the following structures

A.
B.
C.



What two things are made during the Light Reactions?

In one sentence, what is the main idea of the Light Reactions?

What is the waste product of the light reactions?

What is the function of stomata?

What is the function of the vein?

What pigment is always present in the chloroplast?

In one complete sentence, explain how light intensity affects the rate of photosynthesis.

In one complete sentence, explain how temperature affects the rate of photosynthesis.

Why does oxygen decrease the rate of photosynthesis?

In what ways is photosynthesis important to us as humans?

How does the rate of photosynthesis relate to how fast a plant grows?

In which membrane do the Light Reactions take place?

Self-evaluation: How well do you think you understand the concepts of photosynthesis?

Connect Two

Take any two words and connect them to form a sentence about photosynthesis. Each sentence is worth 1 point for a total of 10 points.

_____ and _____ go together because_____.

Terms:

Calvin Cycle	Light	Product
Carbon Dioxide	Light Dependent Reaction	Reactant
Chlorophyll	Light Independent Reaction	Root
Chloroplast	Oxygen	Starch
Glucose	Photosynthesis	Sun
Leaf	Pores	Water

Name Period Date

SECTION 4.2 | OVERVIEW OF PHOTOSYNTHESIS

Reinforcement

KEY CONCEPT The overall process of photosynthesis produces sugars that store chemical energy.

Some organisms, called producers, make their own carbon-based molecules, such as carbohydrates, that are broken down to make ATP. The process that many producers, including plants, use to make their own source of food is called photosynthesis. **Photosynthesis** is a process that captures energy from sunlight to make sugars that store chemical energy.

In plants, photosynthesis takes place in organelles called chloroplasts. Chloroplasts contain molecules, such as **chlorophyll,** that absorb energy from light. Most of a plant's chloroplasts are in leaf cells specialized for photosynthesis. Chloroplasts have two main parts used for photosynthesis: the grana, which contain disk-shaped structures called **thylakoids,** and the stroma, which is the fluid that surrounds the grana. Photosynthesis takes place in two main stages.

- The first stage is called the light-dependent reactions. In the **light-dependent reactions** chlorophyll absorbs energy from sunlight and water molecules are broken down. Energy is transferred to molecules such as ATP. Oxygen is released as a waste product.
- The second stage is called the light-independent reactions. In the **light-independent reactions** energy from the light-dependent reactions is used to build sugar molecules from carbon dioxide.

The overall, simplified chemical equation for the photosynthesis process is:

$$6CO_2 + 6H_2O \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow C_6H_{12}O_6 + 6O_2$$

1. What is photosynthesis?

2. Where does photosynthesis take place in plants?

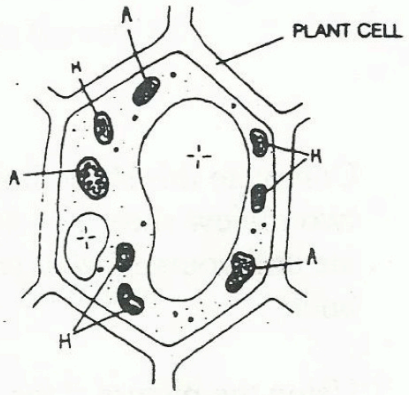
3. What happens during the light-dependent reactions?

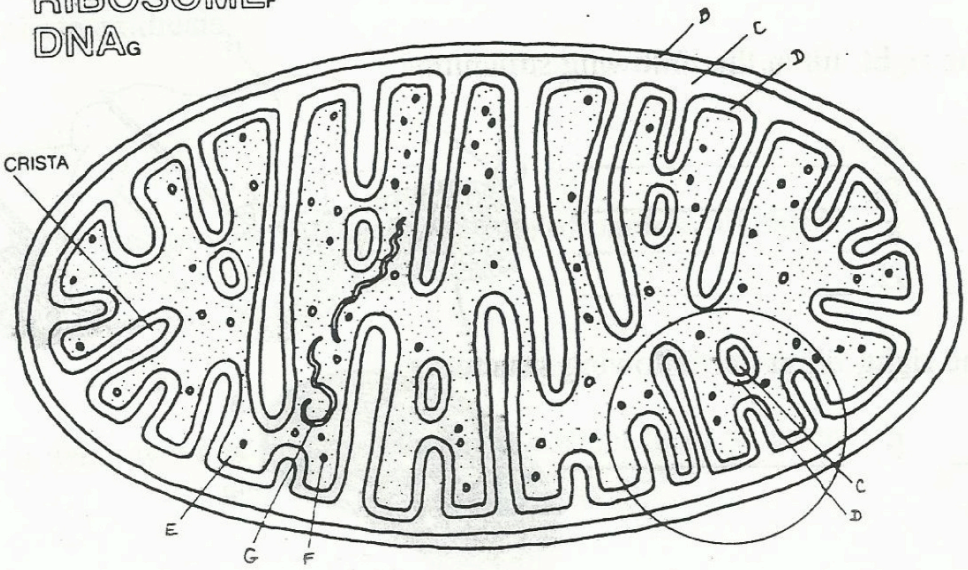
4. What happens during the light-independent reactions?

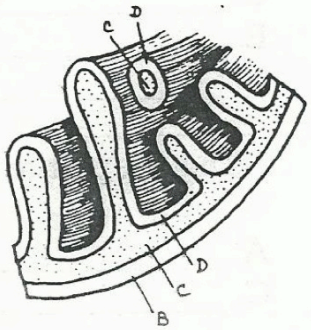
5. What are the reactants and the products of photosynthesis?

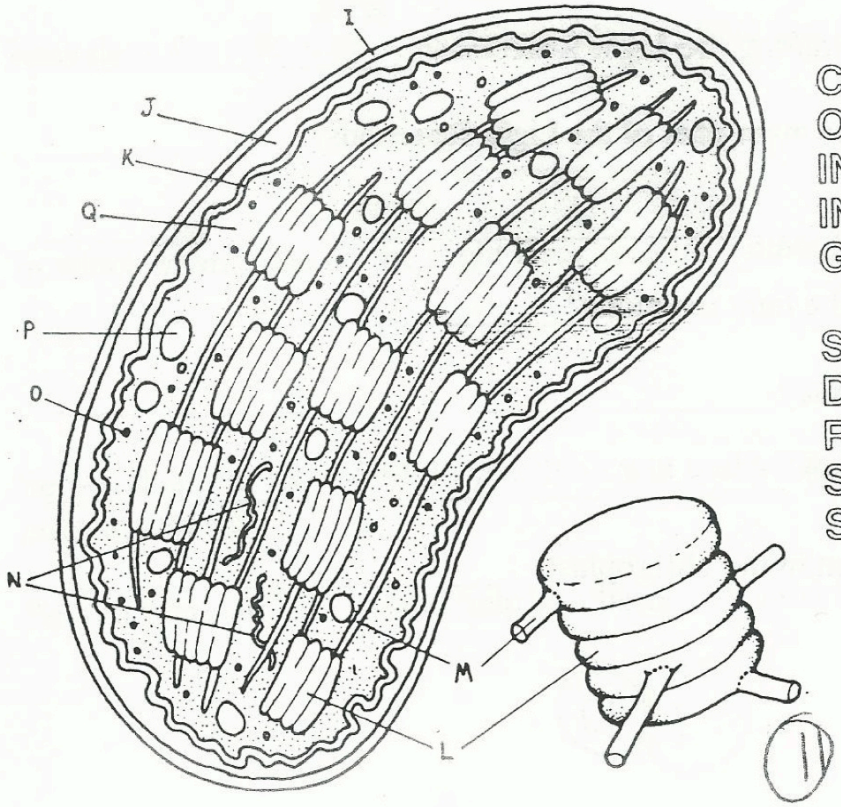
MITOCHONDRION AND CHLOROPLAST.

MITOCHONDRION$_A$
OUTER MEMBRANE$_B$
INTERMEMBRANE SPACE$_C$
INNER MEMBRANE$_D$
MATRIX$_E$
RIBOSOME$_F$
DNA$_G$





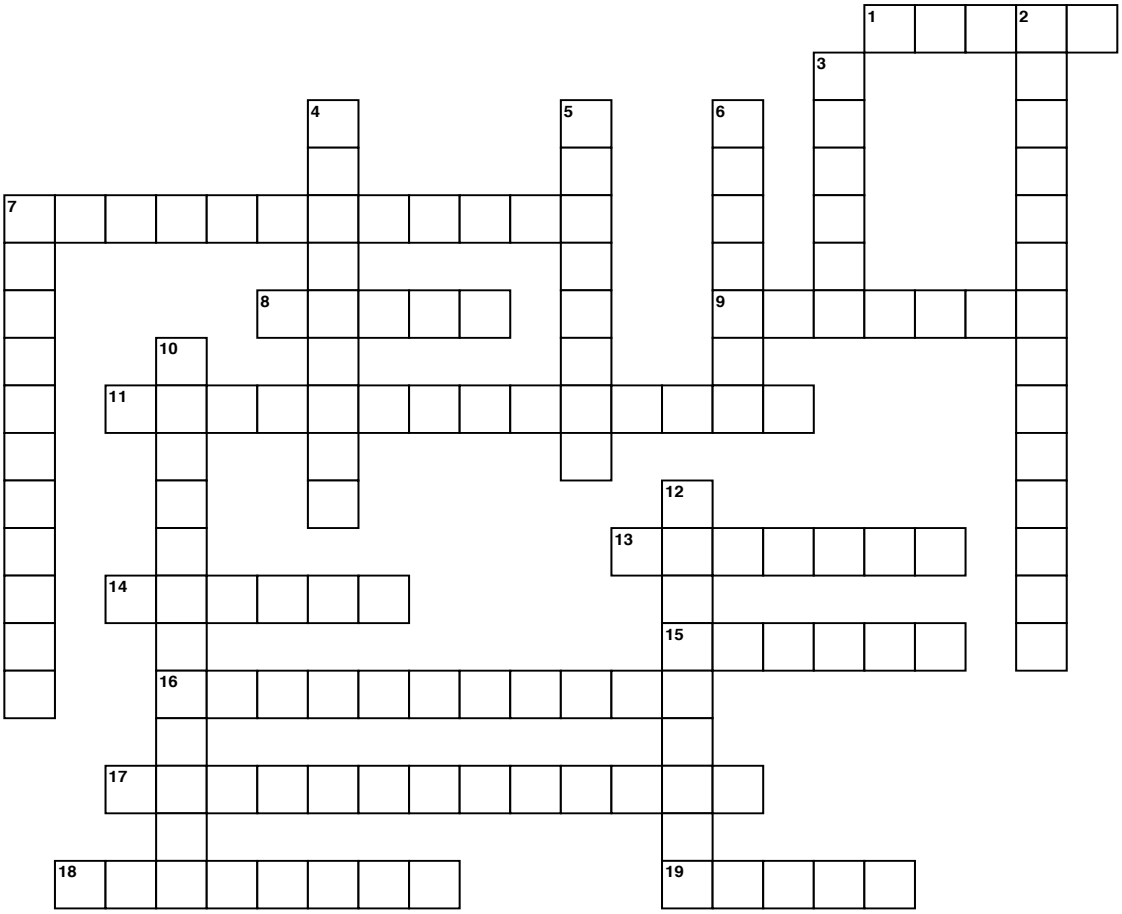




CHLOROPLAST$_H$
OUTER MEMBRANE$_I$
INTERMEMBRANE SPACE$_J$
INNER MEMBRANE$_K$
GRANUM$_\star$
THYLAKOID$_L$
STROMAL LAMELLA$_M$
DNA$_N$
RIBOSOME$_O$
STARCH GRAIN$_P$
STROMA$_Q$

PHOTOSYNTHESIS

CROSSWORD PUZZLE



SOURCE: Rhythm, Rhyme, Results...the other 3 R's. www.educationalrap.com

ACROSS

1 a product of light, water, air and space
7 G3P is an example
8 its formula is H2O
9 a definition for chemical reactions working together
11 another name for Calvin cycle (2 words)
13 a sugar produced by plants
14 the part of a tree that receives sunlight and CO2 for photosynthesis
15 dioxide its formula is CO2 (2 words)
16 a vital part of a plant cell that captures light or carbon dioxide
17 occurs in plants during daylight hours (2 words)
18 captured in 'light' reaction to begin photosynthesis
19 energy type of energy captured in 'light' reaction (2 words)

DOWN

2 process used by plants to convert solar energy to food
3 what plants make that is vital to humans
4 a membrane found in chloroplasts
5 the form of energy photosynthesis transforms sunlight into
6 an enzyme used in photosynthesis
7 also known as 'dark' reaction (2 words)
10 also know as light independent (or absent) reaction (2 words)
12 initiated by the capture of light, these flow through photosystems

Word Bank

Sunlight	NADPH	Water	Rubisco
Solar	Glucose	Chemical	Oxygen
Light reaction	Carbon	Carbon Fixation	Synergy
Chloroplast	Carbohydrate	Photosynthesis	Leaves
Dark Reaction	Thylakoid	Electrons	Calvin Cycle

Illuminating Photosynthesis

- ❑ Type in the following link: http://www.pbs.org/wgbh/nova/methuselah/photosynthesis.html#
- ❑ Read the introduction entitled "Illuminating Photosynthesis" by Rick Groleau
- ❑ Click on the link that reads: "***Go to Illuminating Photosynthesis***."
- ❑ Read the introductory poem.
- ❑ Click on "***The Cycle***" at the top of the box

1. Click on each of the following items, and explain what happens:

a. The ***shade*** over the ***window***: _____

b. The ***container*** of ***water***: _____

c. The ***child***: _____

2. a. What ***gas*** does the child provide for the plant to use? _____

b. What ***gas*** does the plant provide for the child to use? _____

c. Will the plant continue to produce this gas if the shade over the window is closed? (try it out to see!)

3. According to this animation, what 3 main things does the plant need for ***photosynthesis*** to occur?
(1) _____(2) _____(3) _____

- ❑ Click on "***The Atomic Shuffle***" at the top of the box.
- ❑ Read the introductory poem, and click on "***next***"

4. What type of molecule is shown in the leaf? _____

5. Draw one of the molecules below, as it is shown in the leaf.

6. According to the reading, these molecules "do not come from the tap." What two places do they come from?

(1) (2) _____

❑ Click on "***next***" and watch carefully. You may click on "***replay***" to watch this again.

7. a. What is "stripped" from each water molecule?

b. From where does the cell get the energy to do this? _____

c. The stripped molecules form pairs. Where does it go after this?

❑ Click on "***next***"

8. a. What gas enters the leaf? _____

b. This gas enters through "holes" in the leaf. What are they called? _____

❑ Click on "***next***"

9. What molecule is formed ***once again***? _____

❑ Click on "***next***"

10. Another molecule is formed ("and boy is it sweet"). Draw this molecule below as shown.

11. What is the name of this molecule? _____

❑ Click on "***Three Puzzlers***" at the top of the box.

12. Answer each of the following questions, and explain ***in your own words***.

a. Can a tree produce enough oxygen to keep a person alive? Explain.

b. Can a plant stay alive without light?

c. Can a plant survive without oxygen? Explain.

Cell Respiration Notes

Cellular Respiration

The process that releases_____ by breaking down _____

Occurs in _____ living cells

Chemical Formula for respiration

Chemical formula: In words:

Can work with or without oxygen!

Aerobic Cellular Respiration

- Uses _____
- Releases energy

Occurs in 3 stages:

- GLYCOLYSIS
- KREBS CYCLE
- E- TRANSPORT CHAIN

Step 1: _____

- Occurs in the _____
- Glucose is _____ into pyruvic acid
- _____ molecules are produced

Step 2: Krebs Cycle

- Occurs in mitochondria
- Pyruvic acid from glycolysis (step 1) is _____ into CO_2
- _____ molecule is produced

Electron Transport Chain (ETC)

The Krebs Cycle generates _____ that are passed to the electron transport chain

- Here they are used to change _____ to _____
- Water is formed

Totals for Aerobic Respiration

- Production of _____ molecules
- _____ is also released
    - this is why you feel warm after you exercise

Anaerobic Cellular Respiration

- Does not use _____
- Releases energy

Occurs in 2 steps

- Glycolysis
- Lactic Acid Fermentation OR Alcoholic Fermentation

Step 1: Glycolysis – same as in Aerobic Cellular Respiration

Step 2a: _____ Fermentation

- Lactic Acid is produced
- Sore _____ after a workout
- How bacteria makes _____

Step 2b: Alcoholic Fermentation

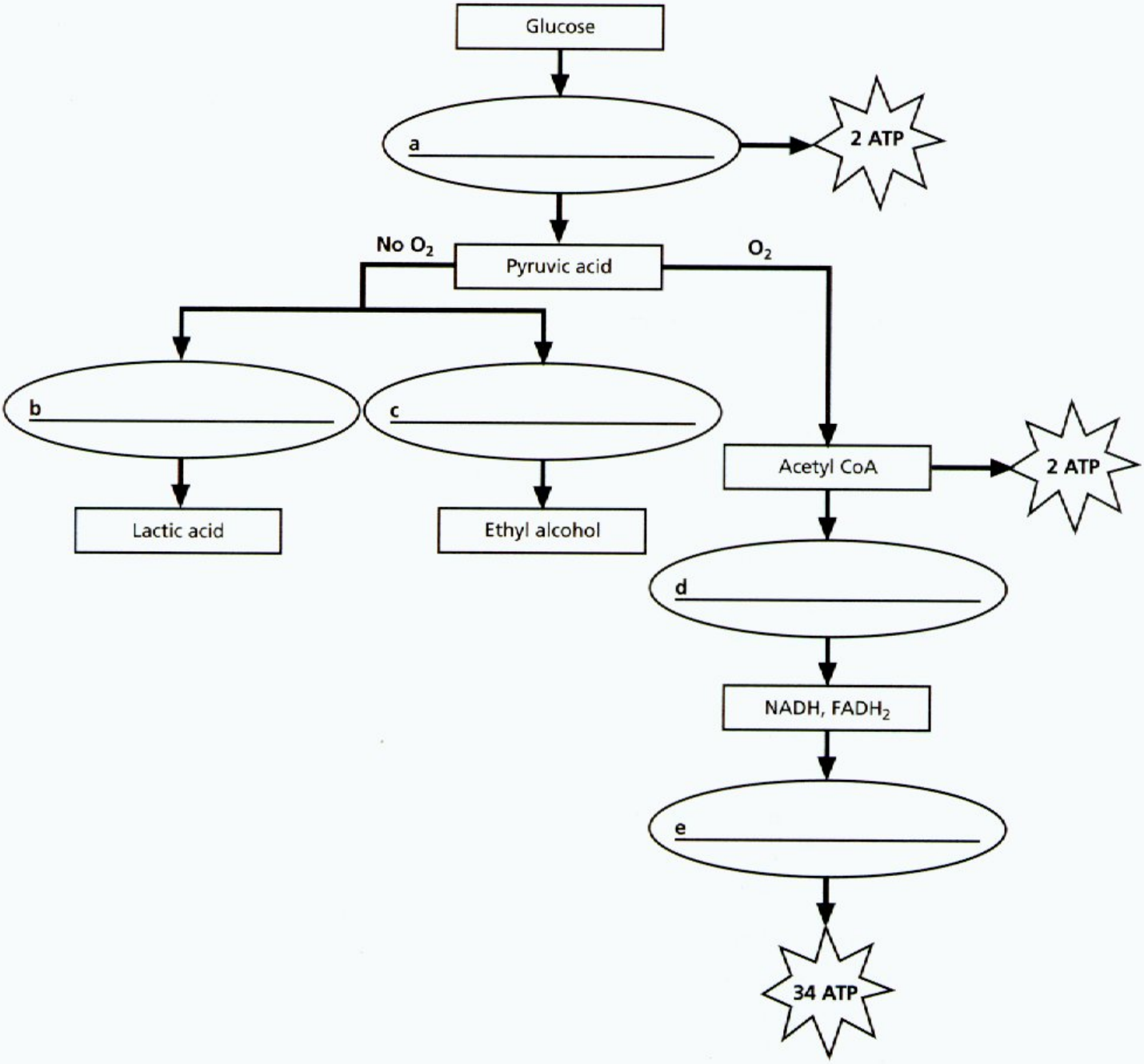
- _____ is produced
- How yeast makes bread

Totals for Anaerobic Respiration

Production of _____ molecules

DRAWING CONCLUSIONS Follow the directions given below.

30. The diagram below depicts the pathways of cellular respiration. Rectangles denote substances involved in cellular respiration and ovals denote processes. Identify the processes by writing the correct term in each blank.



Go to the following link. Read the information and fill in the blanks.
http://encyclopedia.kids.net.au/page/ce/Cellular_respiration

Cellular respiration is, in its broadest definition, the process in which the chemical bonds of _____ rich molecules such as _____are converted into _____ usable for _____ processes. All forms of life except viruses carry out respiration. Oxidation of organic material — in a bonfire, for example — releases a large amount of energy rather_____. The overall equation for the oxidation of glucose is:

_____

In respiration, the process of oxidation is broken down into a large number of steps. These steps are catalysed by _____ and coenzymes; each step releases a small amount of energy in the form of _____. This process consists of two main steps: _____ and _____ breakdown.

Glycolysis does not need _____ in any of its steps. It is a metabolic pathway that is found in all living organisms and it probably _____billions of years ago before the Earth's atmosphere contained oxygen.

- It is the process that converts one molecule of _____into two molecules of _____.
- It _____ energy in the form of two molecules of _____.
- It takes place in the _____ of the plant or animal _____

Breakdown of Pyruvate There are now _____ ways to break down the resulting pyruvate:

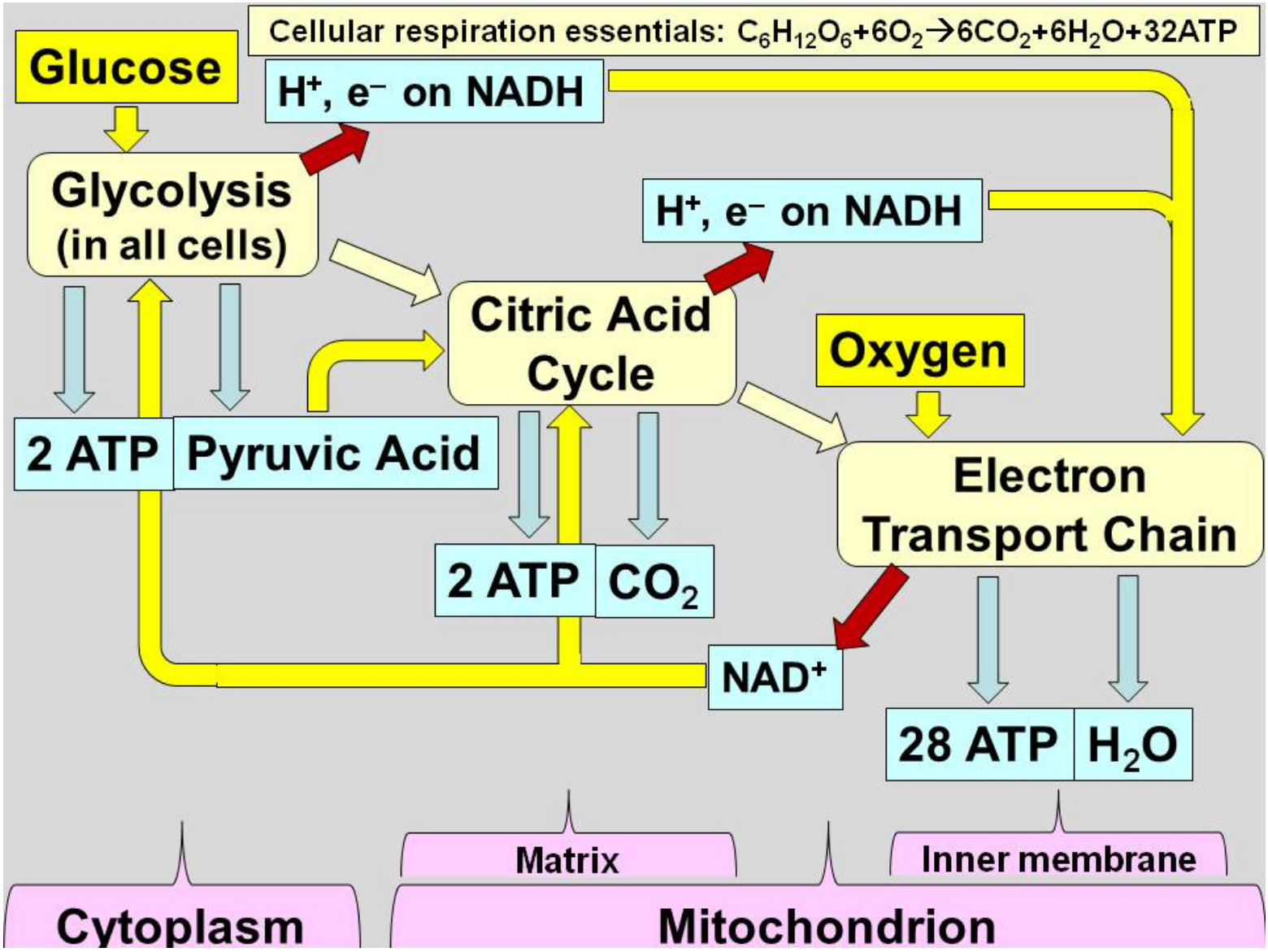
Aerobic respiration requires _____. It is the preferred method of pyruvate breakdown. It yields _____ _____ molecules, as well as _____ _____ and _____. This makes for a total gain of 38 _____ molecules during cellular respiration. This takes place in the _____ of the cells.

Anaerobic respiration _____ require oxygen. In this process, the pyruvate is only partially broken down.

- Fermentation (done by _____ and some types of _____) breaks the pyruvate down into _____, carbon dioxide, and _____. It is important in bread making, brewing, and wine making.
- Lactic acid fermentation breaks the pyruvate down into_____ _____, carbon dioxide, and _____. It occurs in the _____ of animals when they need energy faster than the blood can supply oxygen. It also occurs in some bacteria. It is this

type of bacteria that convert lactose into lactic acid in _____ giving it it's sour taste.

Both ethyl alcohol and lactic acid contain chemical energy that can't be used by anaerobic respiration, making this an inefficient process. Anaerobic respiration releases a total of _____ ATP molecules (compare to the 38 of aerobic respiration).



1. _____- is the first step in cellular respiration that begins with releasing energy stored in glucose.

a. Alcoholic fermentation *b. Lactic acid fermentation* *c. Glycolysis*

2. If oxygen is NOT present, glycolysis is followed by:

a. Kreb's cycle *b. Electron transport chain* *c. Fermentation*

3. Since fermentation does NOT require oxygen, the process is said to be

a. Aerobic *b. Anaerobic*

4. Write the chemical equation using both words and symbols.
5. How is photosynthesis and cellular respiration related?
6. Aerobic respiration requires what element?
7. How many molecules of ATP are at the end aerobic cellular respiration?

a. 2 *b. 24* *c. 36*

8. Which of the following is produced during the Kreb's cycle?

a. ATP *b. NADH* *c. CO_2*

9. ATP means which of the following?

a. Energy *b. Oxygen* *c. Air*

10. Glycolysis happens outside the mitochondria in the _____
11. _____ is produced during glycolysis when glucose splits in half.

a. Carbon dioxide *b. Pyruvic acid* *c. Lactic acid*

12. What cell organelle acts as the cell's power plant?
13. _____ has the formula $C_6H_{12}O_6$ and is split in half during glycolysis.
14. The carbon atoms in pyruvic acid end us as this gas during the Kreb's cycle.

a. Oxygen *b. Carbon dioxide* *c. Hydrogen*

15. Energy is created when ATP is _____phosphate.
16. Which sequence of events is correct for cellular respitation?

a. Electron transport chain → Glycolysis → Kreb's cycle

b. Glycolysis → Kreb's cycle → Electron transport chain

c. Kreb's cycle → Electron transport chain → Glycolysis

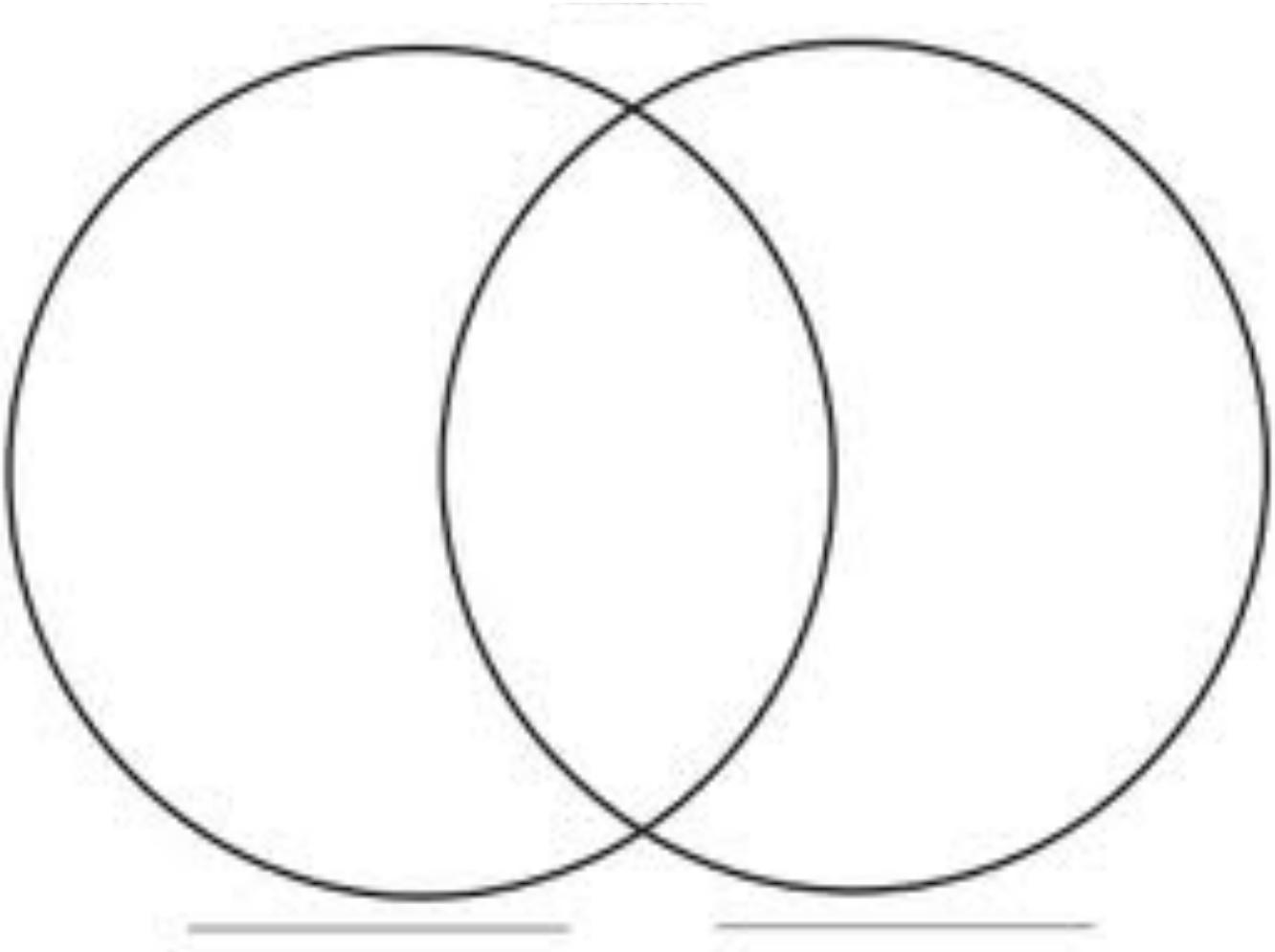
Choose either <u>Alcoholic or Lactic</u> fermentation

17. Yeast uses this to make bread dough rise.
18. Your muscle cells use this during exercise.
19. Bacteria and yeast use this to make beer and wine.
20. Bacteria use this to make cheese and yogurt.

Photosynthesis & Cellular Respiration Venn Diagram

Use each of the cues below to create a Venn diagram comparing and contrasting the process of photosynthesis and the process of cellular respiration (aerobic respiration). For the last three, create your own cues. Remember to keep similarities and differences on the same horizontal plane.

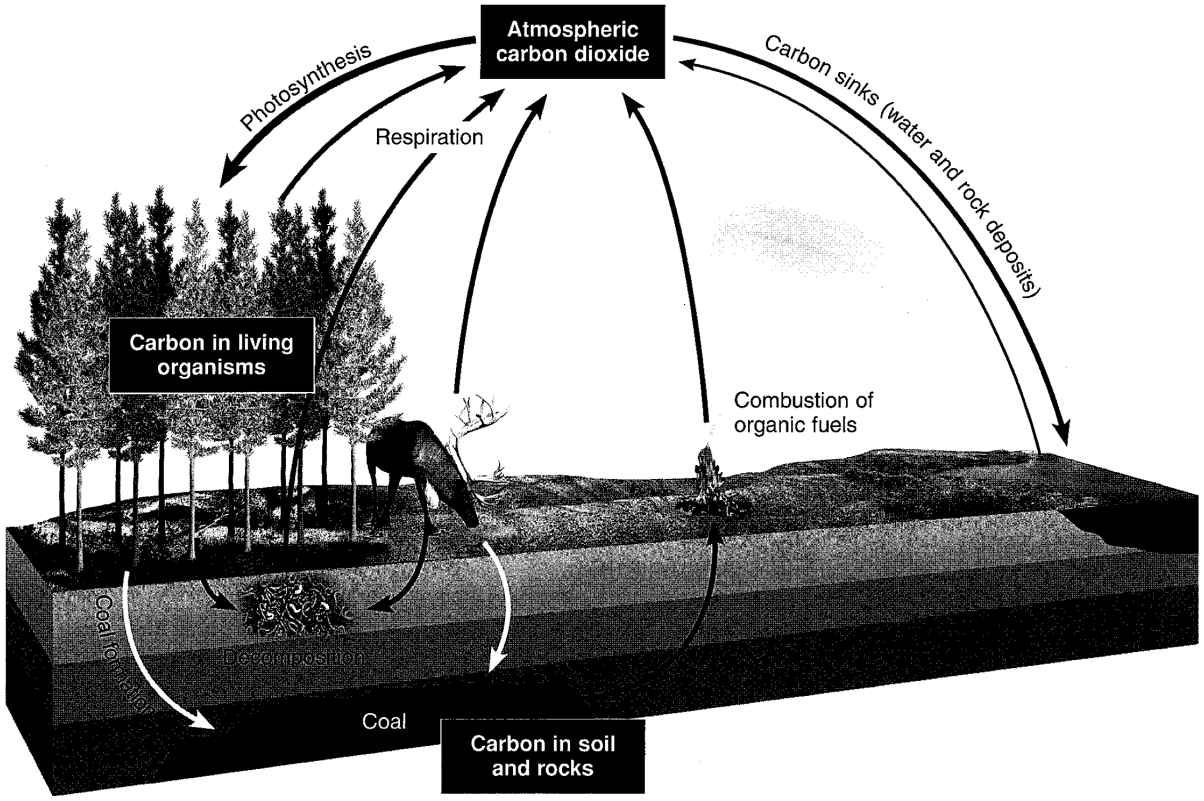
1. Organelle
2. Products
3. Reactants
4. Carrier Molecules
5. Name of Steps
6. Role of water
7. Role of carbon dioxide
8. Role of glucose
9. Role of oxygen



115 The Carbon Cycle

Key Idea: All life is carbon-based. Carbon cycles between the atmosphere, biosphere, geosphere, and hydrosphere. Photosynthesis and respiration are central to this.

- Carbon is the essential element of life. Its unique properties allow it to form an almost infinite number of different molecules. In living systems, the most important of these are carbohydrates, fats, nucleic acids, and proteins.
- Carbon in the atmosphere is found as carbon dioxide (CO_2). In rocks, it is most commonly found as either coal (mostly carbon) or limestone (calcium carbonate).
- The most important processes in the carbon cycle are photosynthesis and respiration.
- Photosynthesis removes carbon from the atmosphere and converts it to organic molecules. This organic carbon may eventually be returned to the atmosphere through respiration.
- Carbon cycles at different rates depending on where it is. On average, carbon remains in the atmosphere as CO_2 for about 5 years, in plants and animals for about 10 years, and in oceans for about 400 years. Carbon can remain in rocks (e.g. coal) for millions of years.



1. (a) In what form is carbon found in the atmosphere? _____

   (b) In what three important molecules is carbon found in living systems? _____

   (c) In what two forms is carbon found in rocks? _____

2. (a) Name two processes that remove carbon from the atmosphere: _____

   (b) Name two processes that add carbon to the atmosphere: _____

3. What is the effect of deforestation and burning of coal and oil on carbon cycling? _____

Ecosystem Modeling

Pre-activity discussion

- How does energy move/cycle through an ecosystem?

- How do we get energy and/or use it?
- How do other organisms do this?
- How is food related to energy?
- How can we observe energy relationships in an ecosystem?

Model development

As a class - list four (4) organisms found in a savannah ecosystem:

Determine who eats whom.

Each student will have a paper bag with an organisms name on it.

Rules of simulation:

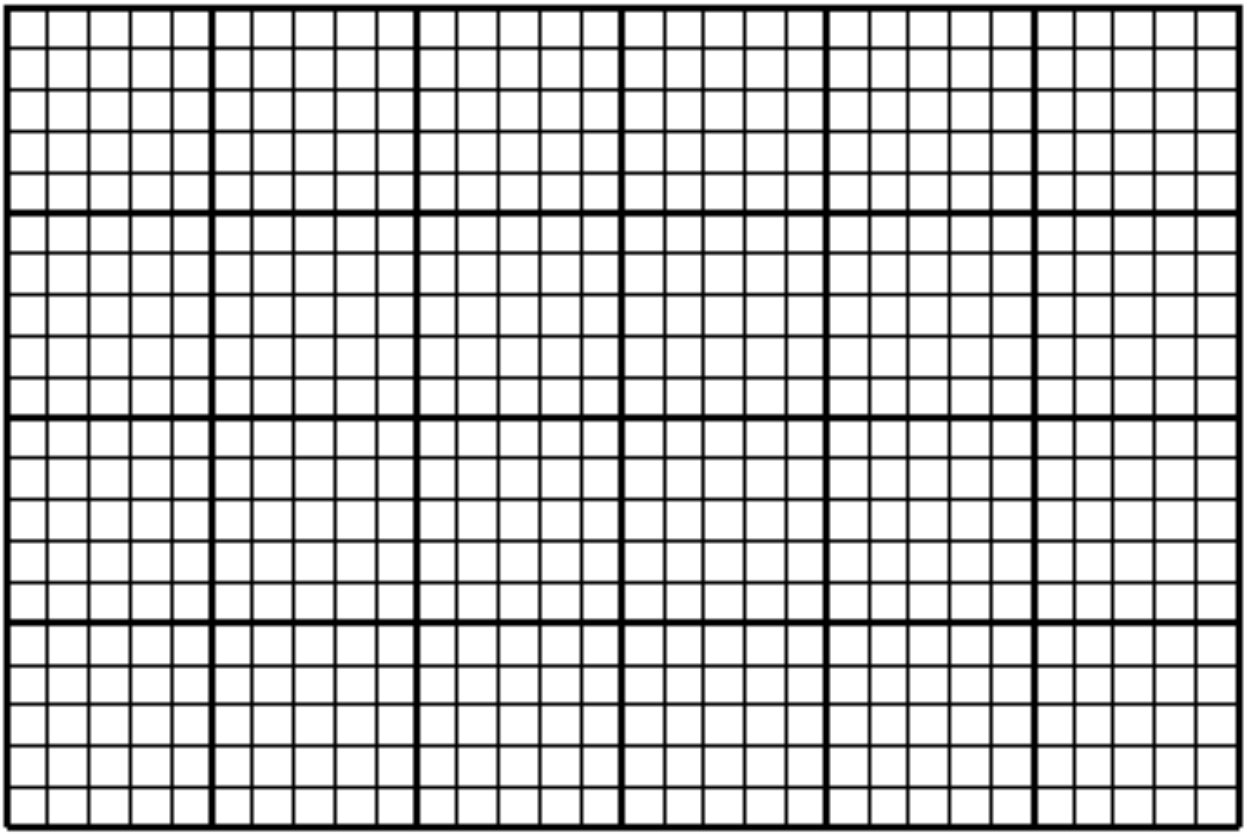
- You must interact with each organism (person in the room) before repeating an interaction
- One organism eats the other - take five beans from their bag - Both put two (2) beans in the waste jar.
- If neither organism eats the other – Both place two (2) beans in the waste jar.
- Plant receives ten (10) beans from the Supply jar after every interaction.
- Only Plant can interact with the Supply jar.
- If you have no beans, you are dead, sit down.

Have each student count their beans.

Record the data for the entire class.

Number of beans				
Total				

Graph the data and prepare to discuss results in a whiteboard meeting with graphical, verbal and pictorial (diagram) representations for the simulation.



Post-activity discussion

- What do the beans represent?

- Which organism finished with the most beans?
- The least?
- Why did this happen?

- What does the supply represent?

- What do we call organisms that get their energy (beans) from the Sun (supply)?

- What are some other organisms that are _____?

- What do we call organisms that eat the producers (ie shrimp eat plankton)?

- What do we call organisms that eat the primary consumers?.
- What do we call organisms that eat the secondary consumers?
- What do we call these eating relationships?
- In your diagram, what do the arrows represent?
    - Which way do the arrows point?
- Can an organism consume more than one other in the diagram?
- What are interconnected feeding relationships are called?
- Why doesn't the top predator eat plants?
    - What happens to the number of beans as you move through the food chain?
    - Where did the energy go?
    - What does the Waste jar represent?
    - Scientists represent energy in a food chain as a pyramid. Why might this be useful?
    - Do all organisms eat everything?
        - Who eats plants?
        - Who eats animals?
        - Who eats both plants and animals?

(HEY! This is a lot of great information! Maybe you could use this to study for a quiz or test…HINT!!)

108 Food Chains

Key Idea: A food chain is a model to illustrate the feeding relationships between organisms.

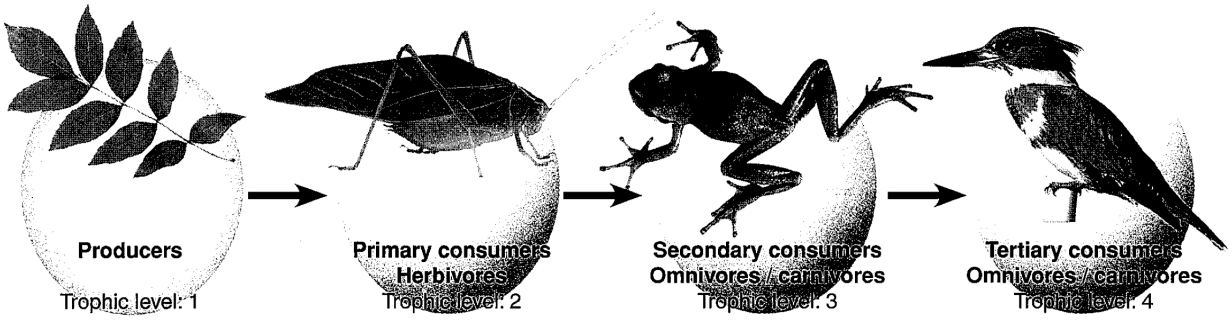
Food chains

Organisms in ecosystems interact in their feeding relationships. These interactions can be shown in a **food chain**, which is a simple model to illustrate how energy, in the form of food, passes from one organism to the next. Each organism in the chain is a food source for the next.

Trophic levels

The levels of a food chain are called **trophic** (feeding) **levels**. An organism is assigned to a trophic level based on its position in the food chain. Organisms may occupy different trophic levels in different food chains or during different stages of their life.

Arrows link the organisms in a food chain. The direction of the arrow shows the flow of energy through the trophic levels. At each link, energy is lost (as heat) from the system. This loss of energy limits how many links can be made. Most food chains begin with a producer, which is eaten by a primary consumer (herbivore). Second (and higher) level consumers eat other consumers, as shown below.

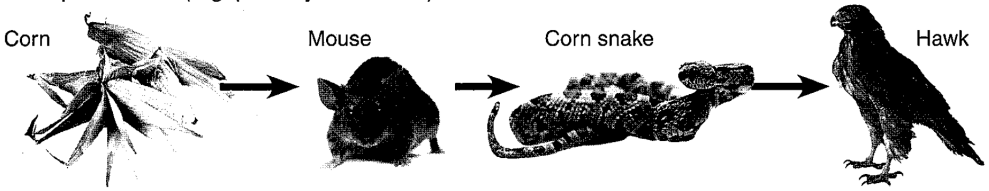


1. What is a food chain? _____

_____

_____

2. (a) A simple food chain for a cropland ecosystem is pictured below. Label the organisms with their trophic level and trophic status (e.g. primary consumer).



Trophic level: _____ _____ _____ _____

Trophic status: _____ _____ _____ _____

(b) What is the original source of energy for this food chain? _____

(c) Why are there are rarely more than five or six links in a food chain? _____

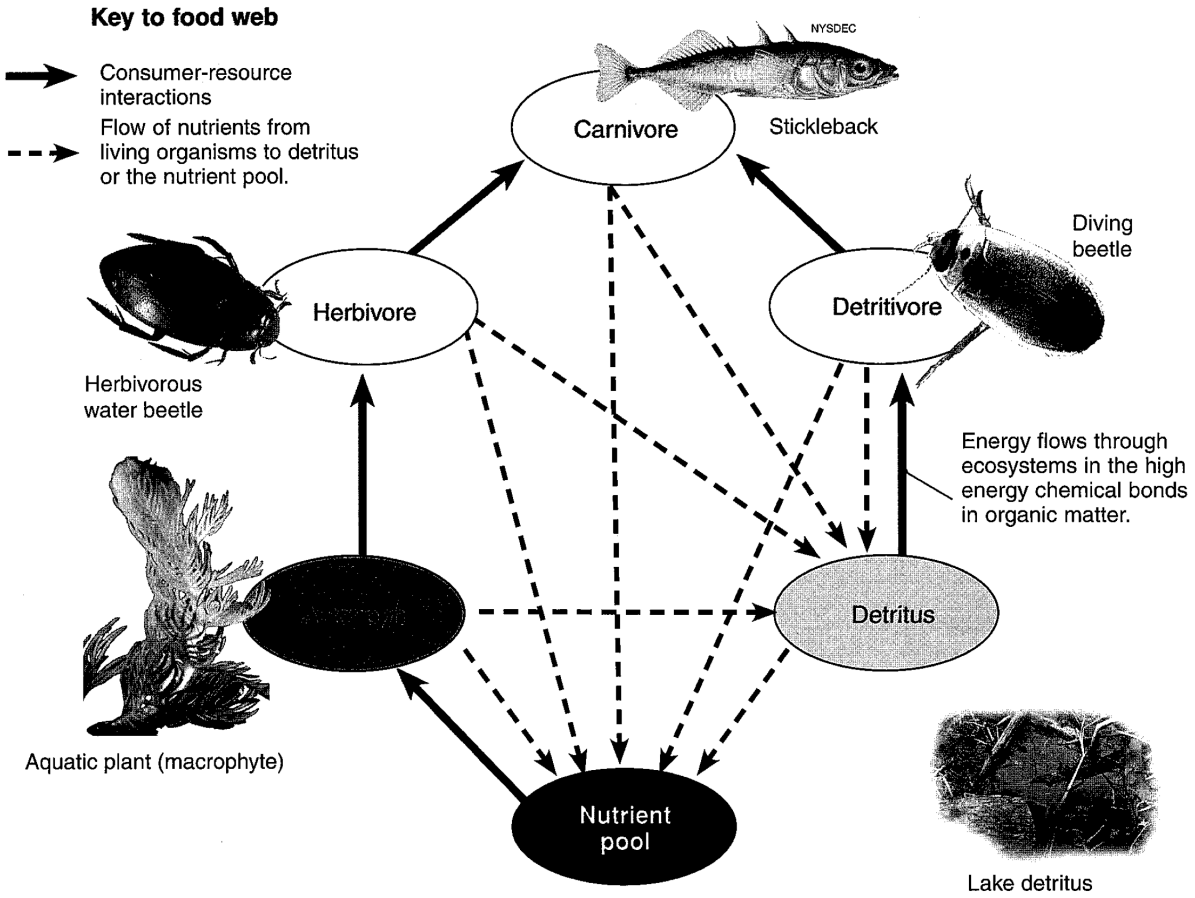
_____

109 Food Webs

Key Idea: A food web consists of all the food chains in an ecosystem. Food webs show the complex feeding relationships between all the organisms in a community.

- If we show all the connections between all the food chains in an ecosystem, we can create a web of interactions called a **food web.** A food web is a model to illustrate the feeding relationships between all the organisms in a community.
- The complexity of a food web depends on the number of different food chains contributing to it. A simple ecosystem, with only a few organisms (and therefore only a few food chains) will have a simpler food web than an ecosystem that has many different food chains.
- A food web model, like the one shown below, can be used to show the linkages between different organisms in a community.

A simple food web for a lake ecosystem



1. What is a food web? _____

_____

_____

2. Why would an ecosystem with only a few different types of organisms have a less complex food web than an ecosystem with many different types of organisms?

_____

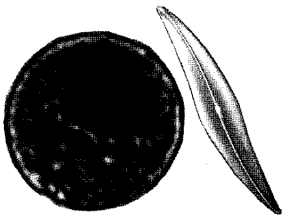
_____

_____

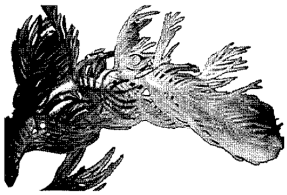
110 Constructing Food Webs

Key Idea: Knowing what the inhabitants of an ecosystem feed on allows food chains to be constructed. Food chains can be used to construct a food web.

The organisms below are typical of those found in many lakes. For simplicity, only a few organisms are represented here. Real lake communities have hundreds of different species interacting together. Your task is to assemble the organisms below into a food web in a way that shows how they are interconnected by their feeding relationships.

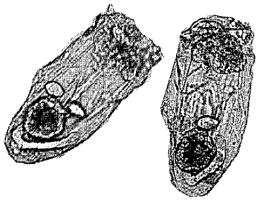


Autotrophic protists (algae)
Chlamydomonas (above left), and some diatoms (above right) photosynthesize.

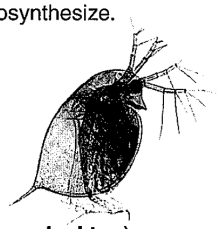


Macrophytes
Aquatic green plants photosynthesize.

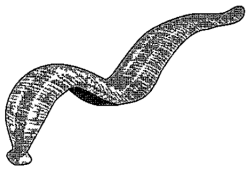
Detritus
Decaying organic matter.



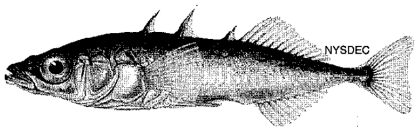
***Asplanchna* (planktonic rotifer)**
A large, carnivorous rotifer.
Diet: Protozoa and young zooplankton (e.g. *Daphnia*).



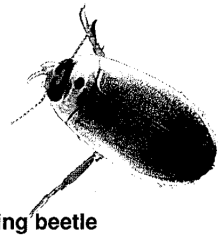
***Daphnia* (zooplankton)**
Small freshwater crustacean.
Diet: Planktonic algae.



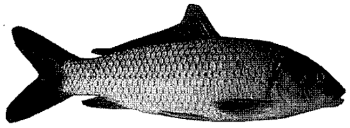
Leech
Fluid feeding predators.
Diet: Small invertebrates, including rotifers, small pond snails, and worms.



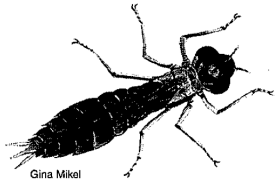
Three-spined stickleback
Common in freshwater ponds and lakes. Diet: Small invertebrates such as *Daphnia* and insect larvae.



Diving beetle
Diet: Aquatic insect larvae and adult insects. The will also eat detritus collected from the bottom mud.



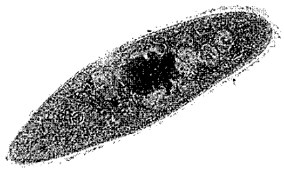
Common carp
Diet: Mainly feeds on bottom living insect larvae and snails, but will also eat some plant material (not algae).



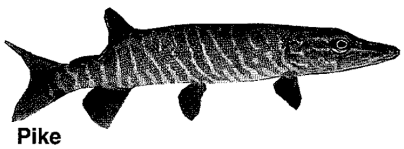
Dragonfly larva
Large aquatic insect larvae.
Diet: Small invertebrates including *Hydra*, *Daphnia*, insect larvae, and leeches.

Great pond snail
Diet: Omnivorous. Main diet is macrophytes but will eat decaying plant and animal material also.

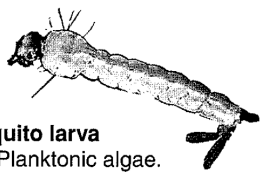
Herbivorous water beetle
Diet: Adults feed on macrophytes. Young beetle larvae are carnivorous, feeding primarily on pond snails.



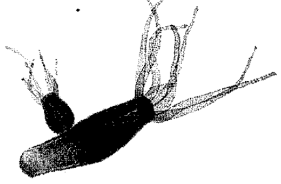
Protozan (e.g. *Paramecium*)
Diet: Mainly bacteria and microscopic green algae such as *Chlamydomonas*.



Pike
Diet: Smaller fish and amphibians. They are also opportunistic predators of rodents and small birds.



Mosquito larva
Diet: Planktonic algae.



Hydra
A small, carnivorous cnidarian.
Diet: small *Daphnia* and insect larvae.

1. From the information provided for the lake food web components on the previous page, construct ten different **food chains** to show the feeding relationships between the organisms. Some food chains may be shorter than others and most species will appear in more than one food chain. An example has been completed for you.

Example 1: Macrophyte → Herbivorous water beetle → Carp → Pike

(a) _____

(b) _____

(c) _____

(d) _____

(e) _____

(f) _____

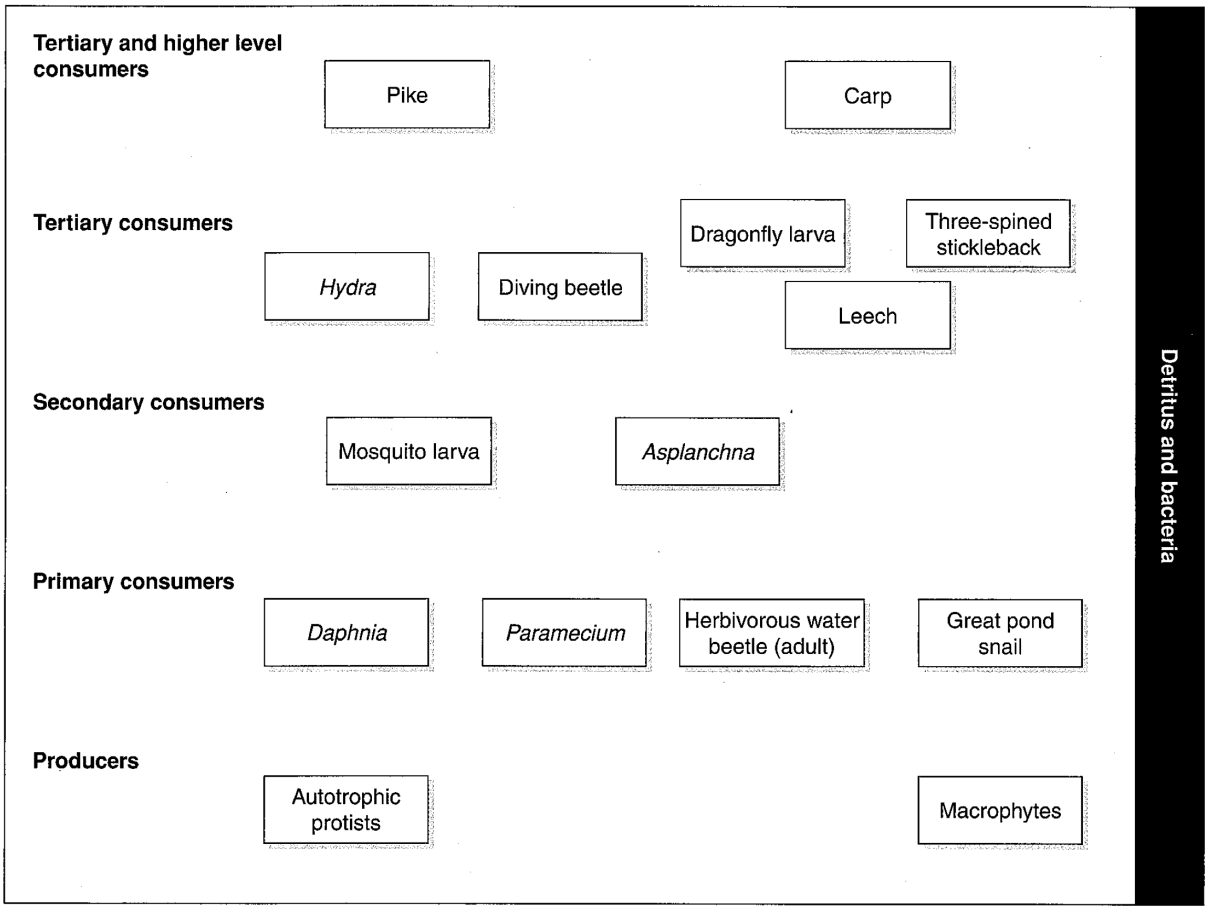
(g) _____

(h) _____

(i) _____

(j) _____

2. Use the food chains you created above to help you to draw up a **food web** for this community in the box below. Use the information supplied on the previous page to draw arrows showing the flow of energy between species (only energy from the detritus is required).



"Energy & Life"

ALL organisms need ENERGY!

Many organisms get energy from food, but that energy originally came from

the…

Plants and some other types of organisms can use_____ from the _____ to produce food. REMEMBER:

- Heterotrophs:
- Autotrophs:

Chemical Energy & ATP
Energy comes in many forms. Examples:

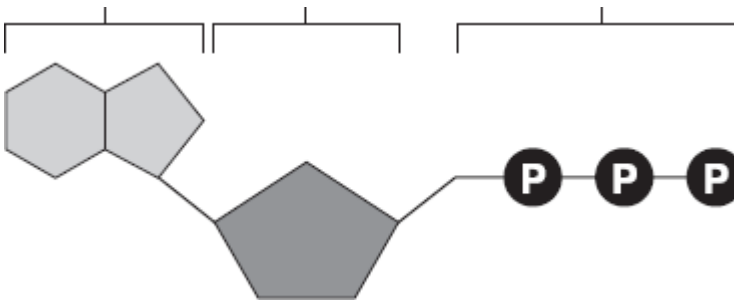
Energy can be stored in chemical bonds too!

Cell activities are powered by:

Cells mainly store energy in the form of:

Adenosine Triphosphate (ATP)
Three main parts:

-
-
-



ATP stores energy for the cell:

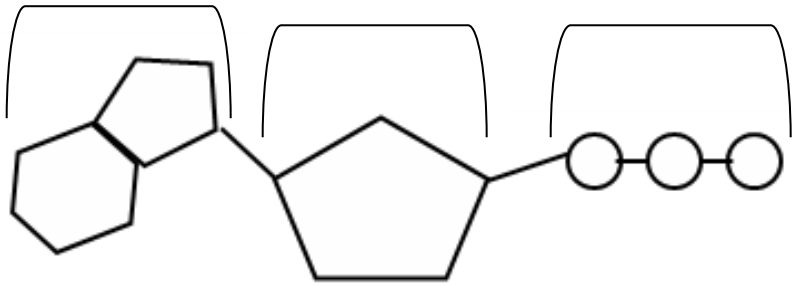
To use energy:

ATP/ADP Cycle:

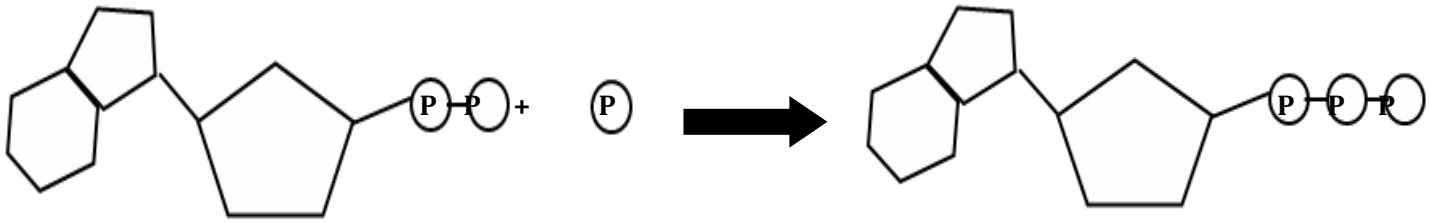
Name: _____ Period: _____

ATP WORKSHEET

1. **Label the three parts of ATP in the molecule below. Color each part a different color.**

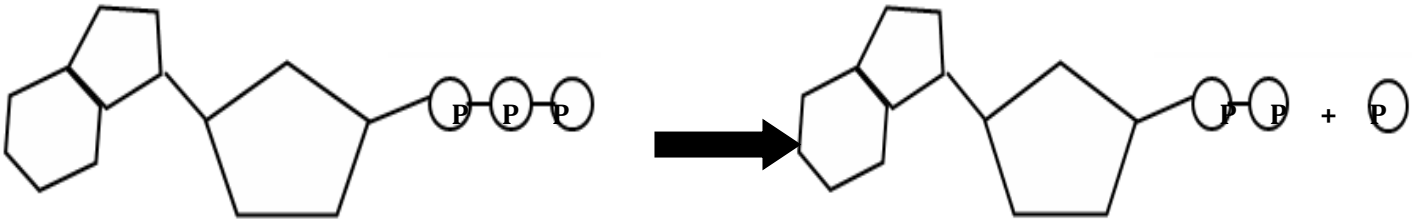


2.



This diagram represents the **energy storing reaction** OR the **energy releasing reaction**

I know this because _____.



This diagram represents the **energy storing reaction** OR the **energy releasing reaction**

I know this because _____.

3. How many phosphate groups (P) are in one molecule of ATP? _____

   How many phosphate groups (P) are in one molecule of ADP? _____

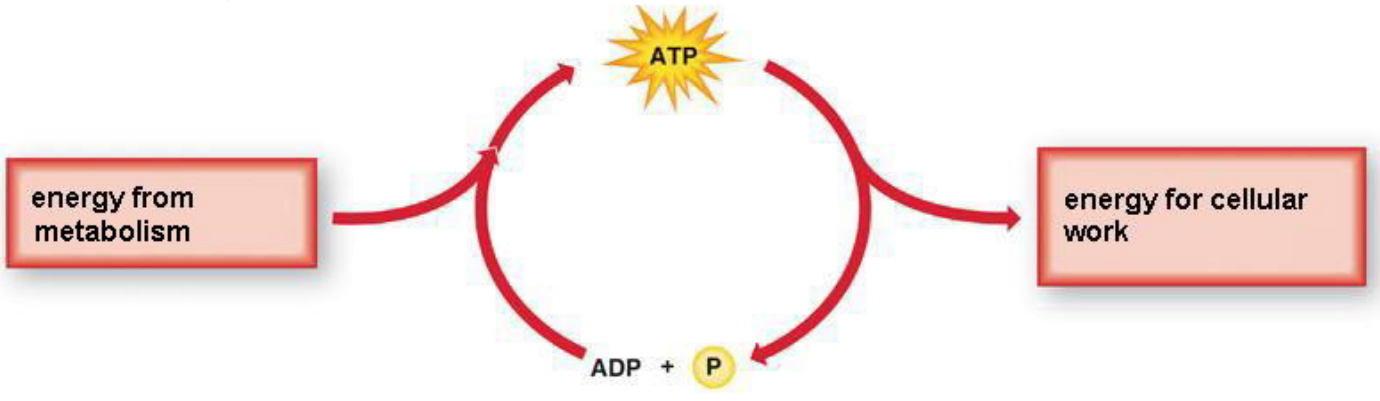
4. How is ATP different from ADP? Which molecule has more energy?

5. How is the ATP molecule like a rechargeable battery?

6. How is a molecule of ATP formed from a molecule of ADP?

7. What functions does ATP serve in cells? Give at least three.

8. How does a change from ATP to ADP provide an organism with energy? Use the figure below to explain this in your own words!



Name: _____ **Period: _____**

Unit 5: Energy Review

PHOTOSYNTHESIS

5. What organelle is responsible for photosynthesis?

6. What is the chemical equation for photosynthesis?

7. What are the products of photosynthesis?

8. What are the reactants of photosynthesis?

9. What pigment captures sunlight and turns plants green?

10. What happens in the light dependent reactions?

11. What happens in the light independent reactions?

12. What gas is used by plants to start photosynthesis?

13. What gas is released by plants during photosynthesis?

14. What factors influence the rate of photosynthesis?

15. What caused the plants to float in spinach disk lab?

16. What happened in the control group of the spinach disk lab?

CELLULAR RESPIRATION

17. What organelle is responsible for cellular respiration?

18. What is the chemical equation for cellular respiration?

16. What are the products of cellular respiration?

20. What are the reactants of cellular respiration?

21. What is aerobic?

22. What is anaerobic?

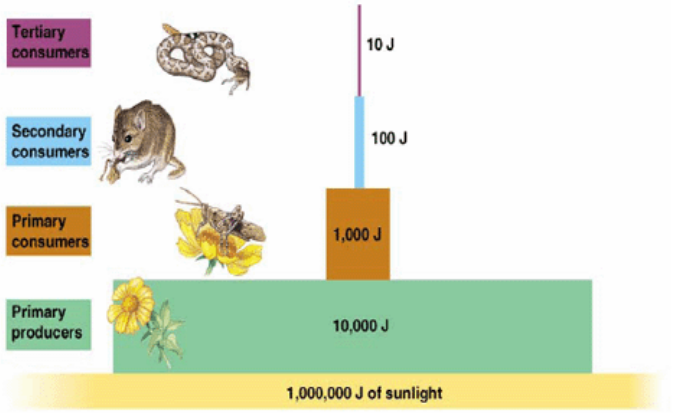
23. What gas is used by eukaryotic cells for cellular respiration?

24. What gas is released by eukaryotic cells for cellular respiration?

Ecosystem

Describe producers, primary consumers, secondary consumers, tertiary consumers.

What is a energy pyramid? (Be able to read a biomass pyramid and a pyramid of numbers)



What is a food chain? (Be prepared to read a food chain)

What is a food web? (Be prepared to read a food chain)

<u>ENERGY CYCLE</u>

1. Where does the energy from planet Earth come from?

2. In what type of cell does photosynthesis occur?

3. In what type of cell does cellular respiration occur?

4. What is ATP?

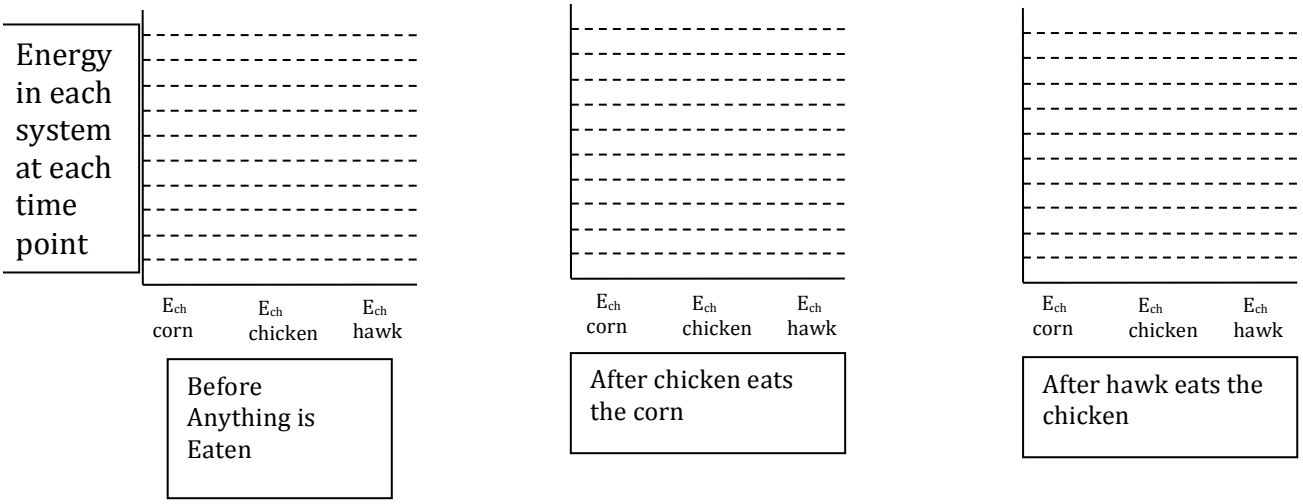
Name_____ Date_____

Unit 4 - Energy Exercise 2

1) A 1000g hawk eats a 1000g chicken which has eaten 50g of corn. We are going to assume that enough time has elapsed for the food to have been fully digested.
   a. NOTE: To answer this question, you need the following information:
      i. Only 2% of the energy taken in by warm-blooded creatures such as mice is used for growth, the rest is transferred out of the system.
      ii. Only 5% of the energy taken in by cold-blooded creatures such as snakes is used for growth, the rest is transferred out of the system.
      iii. The hawk will only eat 600g of the chicken because the other 400g is bones.
   b. Draw a food chain showing the hawk eating the chicken eating the corn.

   c. Label the producer, primary consumer, and secondary consumer in the picture.

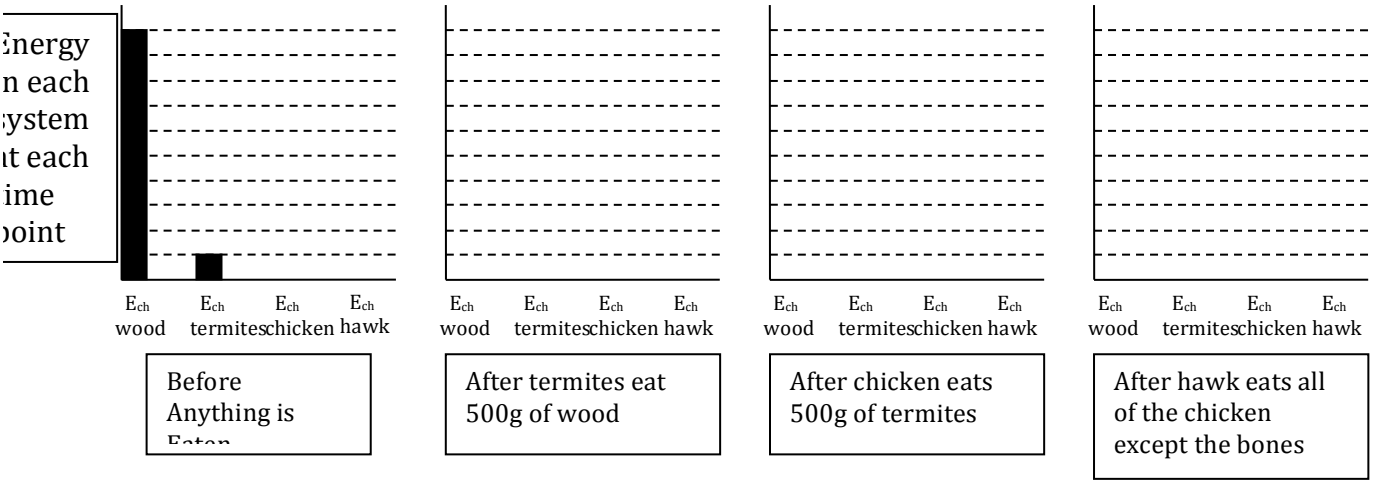
   d. Complete the energy bar graphs below:



2) A 1000g hawk eats a 1000g chicken which has eaten 500g of termites that have eaten 500g of a 1000g pile of dead wood. We are going to assume that enough time has elapsed for the food to have been fully digested.
    a. NOTE: To answer this question, you need the following information:
        i. Only 2% of the energy taken in by warm-blooded creatures such as mice or chickens is used for growth, the rest is transferred out of the system.
        ii. Only 5% of the energy taken in by cold-blooded creatures such as snakes or termites is used for growth, the rest is transferred out of the system.
        iii. The hawk will only eat 600g of the chicken because the other 400g is bones.
    b. Draw a food chain showing the hawk eating the chicken eating the termites eating the wood.

    c. Label the producer, decomposer, primary consumer, and secondary consumer in the picture.

    d. Energy bar chart representations



    e. From where does the energy for the hawk ultimately come? Explain your answer.

f. Draw a food web that contains all of the organisms in questions 1 and 2 as well as other organisms present in the ecosystem.

g. Use the food web you drew above to answer the following questions.
    i. In general, what would happen if there were no producers? Explain using one of these scenarios as a concrete example.

    ii. In general, what would happen if there were no primary consumers? Explain using one of these scenarios as a concrete example.

    iii. In general, what would happen if there were no secondary consumers? Explain using one of these scenarios as a concrete example.

    iv. In general, what would happen if there were no decomposers? Explain using one of these scenarios as a concrete example.

3) Are humans producers, primary consumers, secondary consumers, or decomposers? Justify your answer.

Name: _____

Partner Name: _____

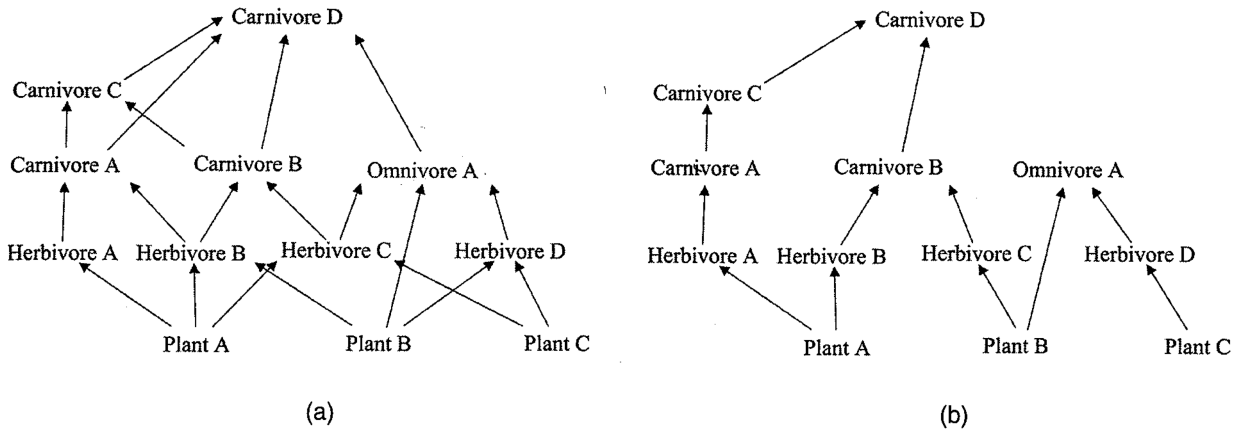
Ecosystems and Biodiversity: How Does Food Web Complexity Affect the Biodiversity of an Ecosystem?

Lab Handout

Introduction

An ecosystem is a community of living organisms and the nonliving components of the environment. Energy flows in an ecosystem in one direction through food chains, and a food web is made up of all the food chains within a community or organisms. Food chains and food webs consist of the producers, (the autotrophs of an ecosystem), the primary consumers (the herbivores and omnivores of the ecosystem), the secondary consumers (the carnivores and omnivores of the ecosystem), and the top predator. Some ecosystems have complex food webs and some do not. In ecosystems with a **complex food web**, herbivores and omnivores eat many different types of plants and the carnivores eat many different types of animals. The consumers in this type of ecosystem are describes as **generalists**. Ecosystems that support consumers that rely on a single food source, in contrast, have **simple food webs, because the consumers are specialists**. An example of a complex food web is provided in panel (a) of the figure below, and an example of a simple food web is provided in panel (b) of that figure.

Example of (a) a complex food web and (b) a simple food web



Biodiversity refers to the variation in species found within an ecosystem, and it is measured in two ways: (1) species richness, which is the total number of different species in an ecosystem; and (2) relative abundance, which is a measure of how common each species is within the ecosystem. Regions that are home to many different species with a high relative abundance of those different species have high levels of biodiversity, whereas regions with only a few different types of species or that have moderate species richness but a low relative abundance of several species have a low level of biodiversity.

Notice that the food webs illustrated above have the same amount of species richness even though the feeding relationships are different. Some of the feeding relationships illustrated in these two ecosystems, however, may or may not be sustainable over time and may result in a net decrease in biodiversity. The relative abundance of each species, for example may change if one or more of the populations within the ecosystem grows or declines over time. The species richness of the ecosystems could also change if some

of the populations disappear because of too much predation or too little access to natural resources. Given the role that biodiversity plays in ecosystem health and tolerance to ecological disturbances, it is important to understand how food web complexity is related to the biodiversity of an ecosystem.

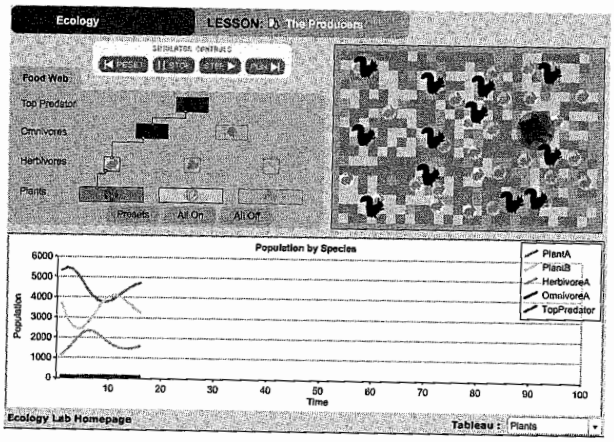
Your Task
Use the online simulation *Ecology Lab* (see figure below) to explore the relationship between food web complexity and biodiversity in an ecosystem.

The guiding question of this investigation is: **How does food web complexity affect the biodiversity of an ecosystem?**

Materials
You will use an online simulation called *Ecology Lab* to conduct your investigation. You can access the simulation by going to the following website: *www.learner.org/courses/envsci/interactives/ecology*. There is a link to this website on Ms. Oiler's Schoolwires page.

Getting started
The *Ecology Lab* simulation allows you to create different food chains and webs within a model ecosystem. Once you establish the food chains and webs in the model ecosystem, you can run the simulation to determine the effect on the population of each organism. To answer the guiding questions, you will need to design and conduct several experiments using the online simulation. To accomplish this task, you must determine what type of data you will need to collect during each experiment, how you will collect it, and how you will analyze it.

A screen shot of the *Ecology Lab* simulation



To determine *what type of data you will need to collect*, think about the following questions:
- What will serve as your dependent variable (population size, number of different populations, relative abundance, and so on)?
- What type of data will you need to keep a record of during your investigation?

To determine *how you will collect your data*, think about the following questions:
- What will serve as a control (or comparison) condition during each experiment?
- What types of treatment conditions will you need to set up for each experiment?
- What variables will you need to control during each experiment?
- How often will you collect data and when will you do it?
- How will you keep track of the data you collect and how will you organize the data?

To determine *how you will analyze your data*, think about the following questions:
- How will you determine if there is a difference between the conditions during each experiment?
- What type of calculations will you need to make?
- What type of table or graph could you create to help make sense of your data?

Investigation Proposal Required ___X__Yes _____No

ADI Laboratory Investigation Proposal C

The Guiding Question…

↓

What data will you collect?

↓

How will you collect your data?

Your Procedure

What safety precaution will you follow?

↓

How will you analyze your data?

Your actual data

I approve of this investigation. _____ _____
Instructor's Signature Date

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

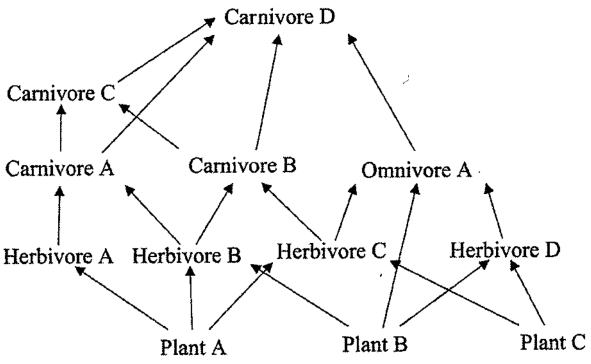
1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!

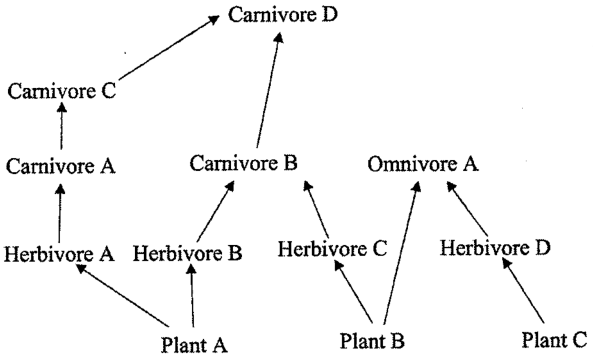
Ecosystems and Biodiversity: How Does Food Web Complexity Affect the Biodiversity of an Ecosystem?

Checkout Questions

Use the figure below to answer questions 1 and 2. The figure illustrates the food webs of two different ecosystems. Ecosystem A has a complex food web and Ecosystem B has a simple one.



Ecosystem A



Ecosystem B

1. Which ecosystem has greater biodiversity?
    a. Ecosystem A
    b. Ecosystem B
    c. Ecosystem A and B have the same amount of biodiversity
    d. Unable to determine from the information provided

    Explain your answer.

2. Which ecosystem is most likely to sustain a greater amount of biodiversity over time?
    a. Ecosystem A
    b. Ecosystem B
    c. Ecosystem A and B both sustain a large amount of biodiversity
    d. Unable to determine from the information provided.

Explain your answer.

3. The inferences that are made by a scientist are influenced by his or her background and past experiences, but the observations made by a scientist are not.
    a. I agree with this statement.
    b. I disagree with this statement.

Explain your answer, using examples from your investigation about ecosystems.

4. Science requires logic and reason but not imagination or creativity.
    a. I agree with this statement.
    b. I disagree with this statement.

Explain your answer, using examples from your investigation about biodiversity.

5. Scientists often attempt to identify patterns in nature. Explain why the identification of patterns is useful in science, using an example from your investigation about ecosystems.

6. An important goal in science is to identify the underlying cause of a natural phenomenon. Explain why it is important for scientists to learn about underlying causes, using an example from your investigation about ecosystems.

7. Scientists often use models to study complex natural phenomenon. Explain what a model is and how you used models during your investigation about ecosystems.

8. Biological systems, such as ecosystems, often go through periods of stability and change. Explain what this means, using an example from your investigation about ecosystems.

Name: _____ Date: _____

Student Exploration: Carbon Cycle

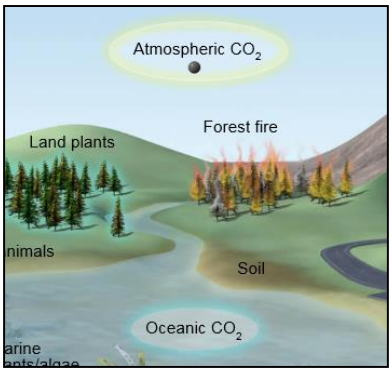
Vocabulary: atmosphere, biomass, biosphere, carbon reservoir, carbon sink, fossil fuel, geosphere, greenhouse gas, hydrosphere, lithosphere, photosynthesis

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
In the process of **photosynthesis**, plants take in carbon dioxide (CO_2) from the atmosphere and water (H_2O) from the soil. Using the energy of sunlight, plants build molecules of glucose ($C_6H_{12}O_6$) and oxygen (O_2).

1. How do plants on Earth affect the amount of carbon in Earth's atmosphere? _____

2. Animals eat plants and produce carbon dioxide and water. How do animals affect the amount of carbon in Earth's atmosphere? _____

Gizmo Warm-up
The *Carbon Cycle* Gizmo™ allows you to follow the many paths an atom of carbon can take through Earth's systems. To begin, notice the black carbon atom in the **Atmospheric CO_2** area, highlighted in yellow. The glowing blue areas represent possible locations the carbon atom could go next.



1. From Earth's atmosphere, where can the carbon atom go next? _____

2. Click on **Land plants** and read the description. How did the carbon atom get from the atmosphere to a plant? _____

3. Select **Land animals**. How did the carbon atom get from land plants into the animal?

4. Select **Atmospheric CO_2**. How did the carbon atom get from land animals back to the atmosphere? _____

Activity A: **Carbon pathways**	Get the Gizmo ready: • Click **Reset**.	

Introduction: Earth can be divided into four systems. The **atmosphere** is the air above Earth's surface. The **hydrosphere** is composed of all of Earth's water. The **geosphere** is the rocky, non-living part of Earth. The **biosphere** consists of all living things, including people. Some scientists use the term "anthroposphere" to describe everything made or modified by humans.

Question: How does carbon move between the atmosphere, hydrosphere, biosphere, and geosphere?

1. Explore: Use the Gizmo to create a path for carbon that begins and ends in the atmosphere. Fill in the steps in the path below. Then, label each location with the system it represents. Finally, summarize very briefly how the carbon atom got to that location.

Carbon path	System	How it got there
Atmospheric CO_2 ↓	Atmosphere	Atmospheric CO_2 comes from volcanoes, burning fossil fuels, and other sources.

2. Create: Click **Reset**. Use the Gizmo to create a path in which the carbon atom goes from the atmosphere to the hydrosphere, biosphere and geosphere. Describe each transition briefly.

Atmosphere	Hydrosphere	Biosphere	Geosphere
Atmospheric CO_2 →	→	→	
Volcanoes, burning fossil fuels, and other sources.			

(Activity A continued on next page)

Activity A (continued from previous page)

3. Explore: Use the Gizmo to create three more carbon paths, each starting and ending in the atmosphere. Label each location with A for atmosphere, B for biosphere, G for geosphere, or H for hydrosphere. (You can also use P for anthroposphere if you like, or just include it in the biosphere.)

   Path 1:

   Path 2:

   Path 3:

4. Explain: Based on the Gizmo, explain how the following transitions might take place:

   A. Describe at least two ways that carbon can get from a land plant to the atmosphere.

   B. Describe at least two ways that carbon can get from the atmosphere to the hydrosphere.

   C. Can you find two ways that carbon can get from the ocean to the **lithosphere**? (The lithosphere is the rigid layer of the Earth, including the crust and part of the mantle.)

   D. Describe at least two ways that carbon can get from seashells to the atmosphere.

Activity B: Human activities	Get the Gizmo ready: • Click **Reset**.	

Introduction: Fossil fuels, such as coal, oil, and natural gas, formed over millions of years from the remains of ancient plants and animals. The burning of fossil fuels, as well as other human activities, increases the amount of carbon dioxide in the atmosphere.

Question: How does human activity affect the carbon cycle?

1. Describe: Using the Gizmo, determine how coal and petroleum (oil) are formed. Describe the steps required to form each fuel from atmospheric CO_2.

   Coal: _____

   _____

   Petroleum: _____

   _____

2. Explore: Natural gas is a mixture of methane (CH_4), ethane (C_2H_6), and other gases. Find two ways that natural gas forms. List the steps of the two carbon pathways below:

   Path 1:

   Path 2:

   How is the formation of natural gas related to the formation of coal and petroleum? _____

   _____

3. Describe: Fossil fuels are used in many ways. Using the Gizmo, describe the main use for each fuel.

   Coal: _____

   Petroleum: _____

   Natural gas: _____

   In each case, what is the end product of burning the fossil fuel, and where does it go?

   _____

(Activity B continued on next page)

Activity B (continued from previous page)

4. Explore: Another major contribution to atmospheric carbon dioxide is the cement industry. Using the Gizmo, find a carbon atom path from the atmosphere to the cement plant. (Hint: One of the ingredients in cement is limestone.)

   Path:

   How is carbon dioxide produced in a cement plant? _____

   _____

5. Analyze: Click **Reset**, then navigate to the **Land animals**. Select **Atmospheric CH_4**.

   A. How do land animals create methane? _____

   _____

   B. Humans raise large numbers of cattle for food. How will these herds of cows affect Earth's atmosphere? _____

   _____

6. Analyze: In many tropical rainforests, people clear land by cutting down trees and burning them. After a few years, the soil runs out of nutrients and cannot be farmed any longer. How does this practice of "slash and burn agriculture" affect Earth's atmosphere?

   _____

   _____

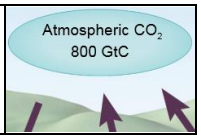
   _____

   _____

7. Draw conclusions: In general, how do many human activities influence the carbon cycle?

   _____

   _____

Activity C: **Modeling the carbon cycle**	Get the Gizmo ready: • Select the MODEL tab.	

Introduction: Humans have been burning fossil fuels rapidly for the past 250 years. As a result, the amount of atmospheric CO_2 has increased by about 40% since the year 1800. By measuring how much carbon moves into and out of the atmosphere, scientists can predict the change in the amount of atmospheric carbon dioxide every year.

Question: How can we model changes in atmospheric carbon over time?

1. Observe: The MODEL tab of the Gizmo shows a greatly simplified model of the carbon cycle. The ovals represent **carbon reservoirs**, where carbon is stored. The arrows represent the movement of carbon from one reservoir to another.

   A. What are the two major sources of atmospheric carbon? _____

   B. A **carbon sink** is a location that stores carbon for a long period of time. What are two carbon sinks that remove carbon from the atmosphere? _____

   C. The unit "GtC" stands for gigatonnes of carbon, where one GtC is equal to one trillion kilograms of carbon. Without making any changes to the Gizmo, list the carbon reservoirs from largest to smallest.

   _____

   Note: The largest carbon reservoir is actually Earth's lithosphere, which contains about 80,000 GtC. However, there is not much exchange between the lithosphere and the other reservoirs on short time scales.

2. Experiment: If necessary, click **Return to original settings**. These settings approximate present-day conditions, but should not be taken as exact values.

   A. What is the total amount of carbon removed from the atmosphere each year by the ocean and land plants? _____

   B. What is the total amount of carbon added to the atmosphere from soil and the burning of fossil fuels? _____

   C. How much will atmospheric carbon change in one year? _____

   In 10 years? _____ In 100 years? _____

(Activity C continued on next page)

Activity C (continued from previous page)

3. Calculate: Carbon dioxide is a **greenhouse gas** that helps to trap heat in Earth's atmosphere. We need some CO_2 in the atmosphere to maintain a warm planet, but excess carbon can cause considerable warming of the planet.

   A. What fossil fuel usage will result in no change in atmospheric CO_2 each year? _____

   B. What percentage decrease in fossil fuel usage is required to achieve this goal? _____

4. Experiment: Using the Gizmo model, explore the following questions:

   A. How does increasing plant **biomass** (amount of plants) affect atmospheric CO_2?

   _____

   B. How does increasing oceanic CO_2 intake affect atmospheric CO_2 and oceanic CO_2?

   _____

   As carbon dioxide is absorbed by the ocean, the ocean becomes slightly more acidic. This could make it harder for many organisms to build their shells and skeletons. The consequences of ocean acidification are not yet fully understood.

5. Infer: Click **Reset** and **Return to original settings**. Suppose we completely stopped burning fossil fuels immediately. How many years would it take to return to atmospheric CO_2 levels from the year 1800, about 600 GtC? Use the Gizmo to find the answer.

   _____

6. Think about it: Since hard-shelled organisms evolved about 550 million years ago, billions of tons of limestone rock have been produced from their shells. Limestone is made of calcium carbonate, with the formula $CaCO_3$.

   Based on this, how do you think the amount of atmospheric CO_2 has changed in the last 550 million years, and how has this affected Earth's climate? Explain your answer.

   _____

   _____

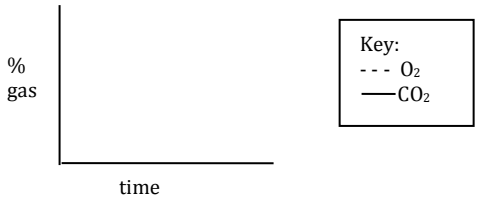
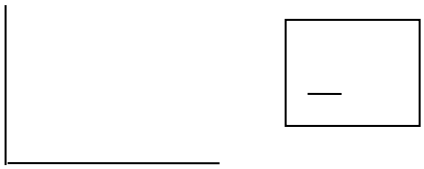
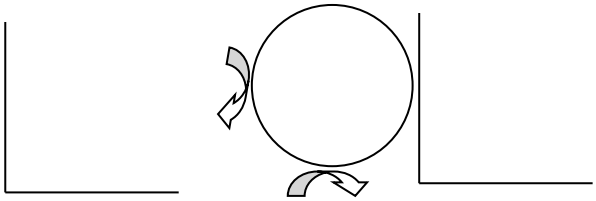
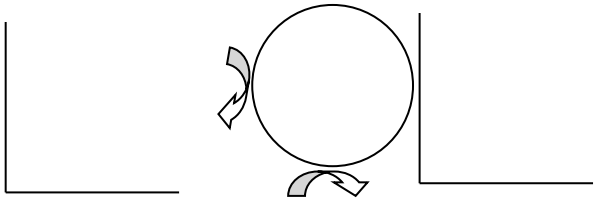
   _____

   _____

Name_____ Date_____

Unit 5 - Energy Exercise 1

1) Complete the following table. Remember this is a summary so keep it simple!

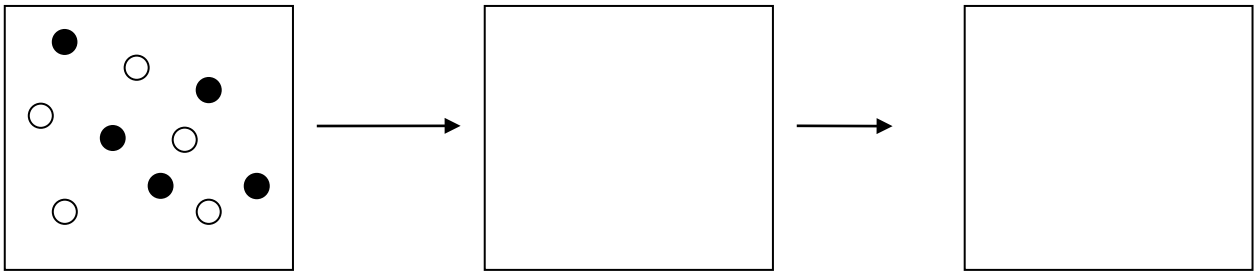
Representation:	**Aerobic**	**Anaerobic**
Equation (Balanced)		
Verbal		
Graphical		
Energy		
Pictorial:		
Multicellular Organism Person		
Cellular		
Molecular	Cytoplasm Mitochondria Matrix	Cytoplasm

2) List the similarities and differences between aerobic and anaerobic respiration.

Similarities	Differences

3) Complete the following evolutionary storyboards for a population of organisms under the following conditions:

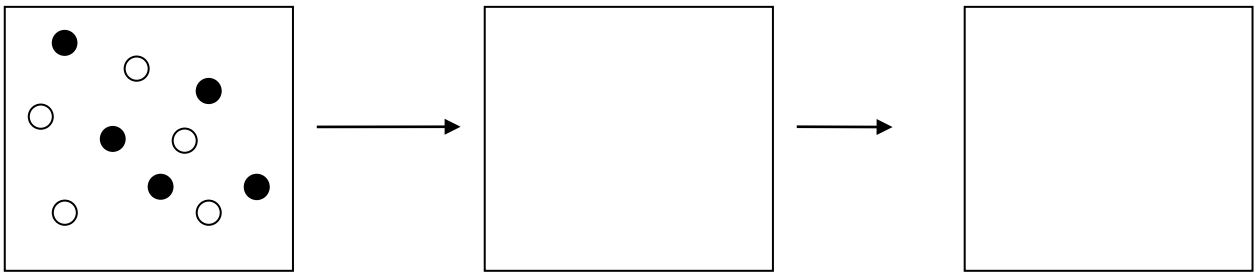
a.



Key: Only able to do aerobic respiration (Obligate aerobe): ●
Able to do both aerobic and anaerobic respiration: ○

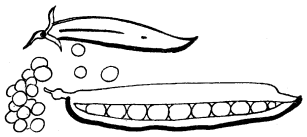
Justify your storyboard:

b.



Key: Only able to do aerobic respiration (Obligate aerobe): ●
Able to do both aerobic and anaerobic respiration: ○

Name:_____ Period: _____



Peas Breathe?
A lab investigating Cellular Respiration in Germinating Seeds

Introduction:
In the last section you learned about photosynthesis. You learned that during photosynthesis chloroplasts take in light energy, water, and carbon dioxide and turn it into glucose and oxygen. During this lab you will explore cellular respiration. During this process mitochondria take in glucose and oxygen and produce carbon dioxide, water along with ATP. So it's easy to see how these two processes are so closely tied together. They are like peas and carrots!

Pre Lab Questions:

- Write the equation for cellular respiration.

- What is ATP? Briefly describe its function. Why is it an important molecule?

In this lab you will use Peas to observe cellular respiration happening. What you will be doing in this experiment is taking some peas that have been soaked in water. Soaking them in water 'wakes them up' and they start to germinate…or grow. In order for growth to take place they need energy. They will get that energy from cellular respiration. The peas that have not been soaked in water are still dormant – or asleep. They will wait and wait until the conditions are right to grow.

- Which peas should be performing cellular respiration? Which ones will not be performing cellular respiration?

- Knowing the formula for cellular respiration, what gas is going to be used up by the germinating seed during the experiment?

Purpose: To investigate cellular respiration in germinating seeds.

Variables:

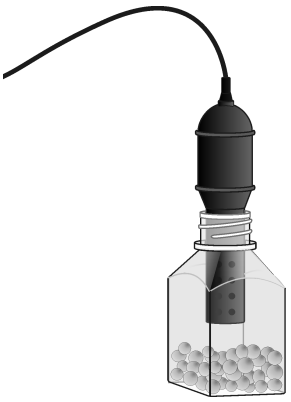
- Independent Variable: _____
- Dependent Variable: _____
- Control Group: _____

Hypothesis: The _____ (what type of peas) will undergo cellular respiration by using oxygen and stored energy to produce carbon dioxide and water because _____.

Materials:

LabQuest	25 germinated peas (wet peas)	25 non-germinated peas (dry peas)
Vernier CO_2 Gas Sensor	Respiration Chamber	

Procedures: Using the CO_2 Gas Sensor, you will monitor the carbon dioxide produced by peas during cell respiration. Both germinated and non-germinated peas will be tested.



1. If the CO_2 Gas Sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the CO_2 Gas Sensor to LabQuest and choose New from the File menu.
2. On the Sensor screen, tap Duration, change the data-collection duration to 300 seconds, and then select OK.
3. Obtain 25 germinated peas and blot them dry between two pieces of paper towel.
4. Place the germinated peas into the respiration chamber.
5. Place the shaft of the CO_2 Gas Sensor in the opening of the respiration chamber.
6. Wait one minute, then start data collection.
7. When data collection has finished, a graph of carbon dioxide gas *vs.* time will be displayed.
8. Perform a linear regression to calculate the rate of respiration.
   a. Choose Curve Fit from the Analyze menu.
   b. Select Linear for the Fit Equation. The linear-regression statistics for these two data columns are displayed for the equation in the form

      $$y = mx + b$$

      where x is time, y is CO_2 concentration, m is the slope, and b is the y-intercept.
   c. Enter the slope, m, as the rate of respiration in Table 1.
   d. Select OK.
9. Repeat Steps 3–8 substituting the germinated peas with non-germinated peas.

DATA

Table 1	
Peas	Rate of respiration (ppm/s)
Germinated, room temperature	
Non-germinated, room temperature	

Data Analysis:

1. What is the equation for cellular respiration?

_____

2. What part(s) of the lab was experiencing cellular respiration?
3. How did pre-soaking the peas affect the rates of cellular respiration? Why? Hint: think about what a seed needs to grow into a plant.
4. If your peas had been placed in the refrigerator for 24 hours instead of being left at room temperature, how do you think this would have affected the results? Why?

Name: _____ Date: _____

Student Exploration: Photosynthesis Lab

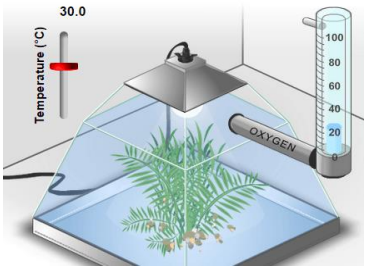
Vocabulary: carbon dioxide, chlorophyll, glucose, limiting factor, nanometer, photosynthesis, wavelength

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

- To survive, what gas do we need to breathe in? _____
- Where is this gas produced? _____

Gizmo Warm-up

During **photosynthesis**, plants use the energy of light to produce **glucose** ($C_6H_{12}O_6$) from **carbon dioxide** (CO_2), and water (H_2O). Glucose is a simple sugar that plants use for energy and as a building block for larger molecules.



A by-product of photosynthesis is oxygen. Plants use some of the oxygen they produce, but most of it is released. In the *Photosynthesis Lab* Gizmo™, you can monitor the rate of photosynthesis by measuring oxygen production.

1. Observe the left pane closely. What do you think the bubbles are? _____

2. Select the BAR CHART tab. On the graph, notice the **Oxygen production** bar. Move the **Light intensity** slider back and forth. How does light intensity affect oxygen production?

   _____

3. Experiment with the vertical **Temperature** slider (upper left) and the **CO_2 level** slider.

   A. How does temperature affect oxygen production? _____

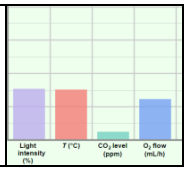
   _____

   B. How does CO_2 level affect oxygen production? _____

   _____

   C. How does oxygen production relate to the rate of photosynthesis? _____

   _____

Activity A: **Ideal conditions**	Get the Gizmo ready: • Be sure that the BAR CHART tab is selected. • Turn on **Show numerical values**.	

Question: In the Gizmo, what are the ideal conditions for photosynthesis?

1. Form hypothesis: During photosynthesis, light energy is used to synthesize carbon dioxide (CO_2) and water (H_2O) into glucose ($C_6H_{12}O_6$) and oxygen (O_2). The complex series of chemical reactions is summarized by the following formula:

   $$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

   In the Gizmo, what light intensity and CO_2 level do you think will maximize the rate of photosynthesis? _____

2. Experiment: Use the Gizmo to find the ideal conditions for photosynthesis. Use any method you like. When you think you have the answer, list the conditions below.

Temperature	Light intensity	CO_2 level	Oxygen production

3. Revise and repeat: One way to test if you've found the ideal conditions is to change each variable slightly from the value that you recorded above. If the oxygen production decreases with each change that you make, it is likely you have found the ideal conditions. If a small change causes oxygen production to increase, continue to experiment.

   If necessary, revise your numbers in the table above.

4. Think and discuss: Think about the process of finding the ideal conditions.

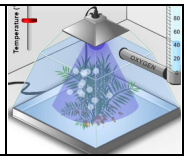
   A. Why would it be hard to find the ideal light intensity if the temperature were very hot or cold? _____

   _____

   B. Why would it be hard to find the ideal CO_2 level if the light intensity were very low?

   _____

   _____

Activity B: **Colored light**	Get the Gizmo ready: • Select the COLOR tab and the BAR CHART tab. • Set the **Temperature** to 24°C, the **Light intensity** to 90%, and the **CO_2 level** to 1,000 ppm.	

Introduction: Plants use a green pigment called **chlorophyll** to absorb light and convert its energy into a form that the plant can use. Chlorophyll gives plants their green color.

Question: What color of light is the best for photosynthesis?

1. Observe: The color of a light wave is determined by its **wavelength**. On the COLOR tab, slowly drag the **Light wavelength** slider back and forth and observe the effect on oxygen production. How does the color of light affect the rate of photosynthesis?

   _____

   _____

2. Form hypothesis: Which color of light do you think will maximize the rate of photosynthesis?

   _____

3. Gather data: Set the **Light wavelength** to 400 nm. (The symbol "nm" stands for **nanometers**. A nanometer is a billionth of a meter.) Visible light ranges from 400 to 700 nm.

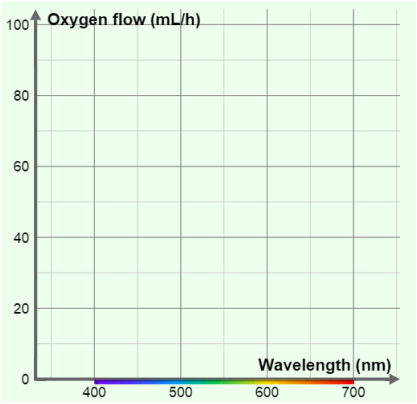
   On the TABLE tab, click **Record data**. Then set the **Light wavelength** to 420 nm, and repeat. Continue recording data in the Gizmo every 20 nm until the wavelength is 700 nm.

4. Make a graph: Select the GRAPH tab and select **Wavelength**. Sketch the graph in the space at right.

   A. Which colors were absorbed best by the plant? _____

   B. Which colors were absorbed worst?

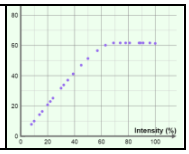
   _____



5. Think and discuss: When we look at a leaf, we see the colors of light that are reflected off its surface. How does this explain the relatively low flow of oxygen in green light?

   _____

   _____

Extension: **Limiting factors**	Get the Gizmo ready: • Select the WHITE tab and the BAR CHART tab. • Turn on **Show numerical values**.	

Introduction: Photosynthesis requires light, water, and CO_2 to work. When one of these factors is in short supply, it is called a **limiting factor**. Temperature can also be a limiting factor when it is too hot or too cold for photosynthesis to work well.

Question: What is the effect of limiting factors on photosynthesis?

1. Observe: Set **Temperature** to 24°C, **Light intensity** to 50%, and **CO_2 level** to 200 ppm.
   A. Move the **Temperature** slider up and down. Were you able to increase oxygen production? _____ (Return the slider to 24°C when finished.)
   B. Move the **Light intensity** slider back and forth. Were you able to increase oxygen production? _____ (Return the slider to 50% when finished.)
   C. Move the **CO_2 level** slider back and forth. Were you able to increase oxygen production? _____ (Return the slider to 200 ppm when finished.)

2. Analyze: In this situation, what was the limiting factor? _____
   How do you know? _____
   _____

3. Challenge: In each of the situations below, use the Gizmo to find the limiting factor.

Temperature	Light intensity	CO_2 level	Limiting factor
25°C	60%	700 ppm	
15°C	20%	200 ppm	
30°C	50%	400 ppm	

4. Think and discuss: Suppose you were a farmer trying to grow plants in a greenhouse. Why would it be important to know what the limiting factor is?
   _____
   _____

Name: _____

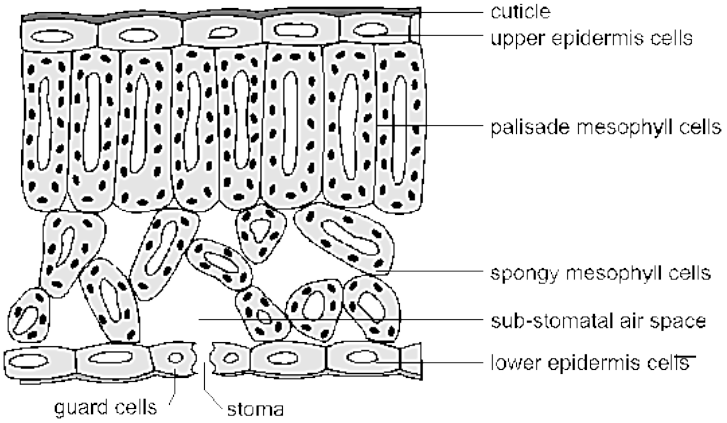
Photosynthesis Investigation[1]

Part 1. **Measuring the Rate of Photosynthesis**

You will use the "floating leaf disk" method to measure the rate of photosynthesis. To begin, cut several disks from a spinach leaf and put these leaf disks in a cup of water.

1. Do your leaf disks float?

Use the information in this diagram of a cross-section of a leaf to explain why a leaf disk would float.



The white oval in the center of each cell represents a vacuole which is filled with water with dissolved substances. The dark spots in the mesophyll cells represent chloroplasts.

2. Where does photosynthesis occur in a leaf? State which organelles carry out photosynthesis and which type or types of leaf cells have this organelle.

3. Explain why it is useful to the plant to have air spaces around the spongy mesophyll cells in the leaves. (Hint: Recall the chemical equation for photosynthesis:

$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6\,O_2)$$

[1] Adapted from Investigation 5 in College Board Teacher Manual for AP Biology Investigative Labs, http://www.collegeboard.com/html/apcourseaudit/courses/pdfs/cb-biology-lab-manual-1-24-12.pdf by Drs. Ingrid Waldron, Linda Robinson and Scott Poethig, Department of Biology, University of Pennsylvania, © 2016. This Student Handout and Teacher Preparation Notes with instructional suggestions and background information are available at http://serendip.brynmawr.edu/sci_edu/waldron/#photosynthesis.

4. To measure the rate of photosynthesis, you will replace the air in the spongy mesophyll in your leaf disks with a liquid. This will cause the leaf disks to sink. Then you will put these leaf disks in water with dissolved CO_2 and measure the amount of time it takes for the leaf disks to float. Which product of photosynthesis will accumulate in the spongy mesophyll and cause the leaf disks to float?

For photosynthesis to occur in the leaf disks that have had the air sucked out, you will ned to provide the leaf disks with light and a good source of CO_2 dissolved in water. For this purpose, you will use a solution of sodium bicarbonate ($NaHCO_3$) in water. Sodium bicarbonate reacts with water as follows:

$$NaHCO_3 + H_2O \leftrightarrow \quad NaOH + H_2CO_3 \leftrightarrow NaOH + H_2O + CO_2$$

5. As a control, you will put some leaf disks in water (with no sodium bicarbonate). Do you expect these leaf disks to float? ___ yes ___ no
Explain your reasoning.

Spinach Disc Lab Answer Sheet
PRE-LAB

Research Question: What do you want to know?

Independent variable: what experimental factor will you change to produce an outcome?

Dependent variable: what will you measure? Will you collect quantitative data or qualitative data?

Control group: what kind of control group will you establish as a standard for comparison?

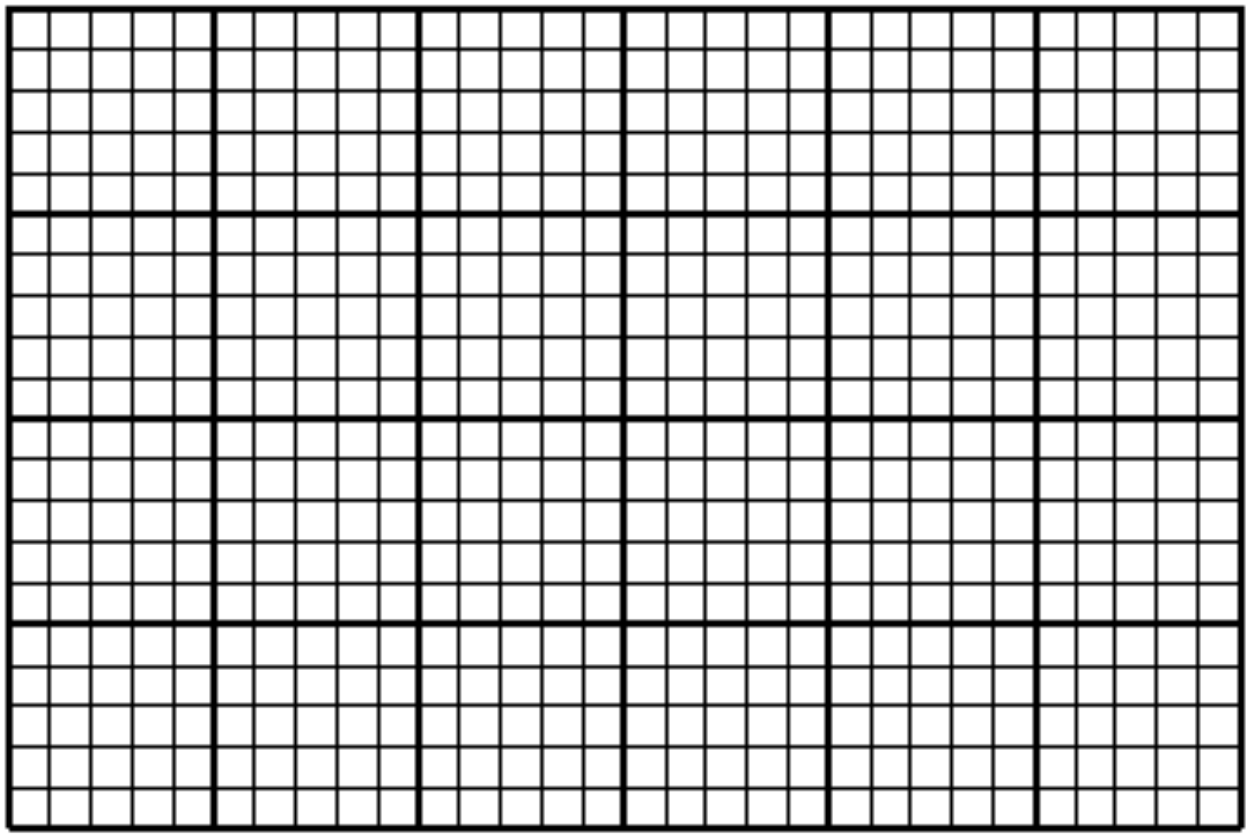
Constants: what conditions will you keep constant? Name at least 3.

DURING LAB

Results: Number of Spinach Disks Floating

	Time (minutes)															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
In Water																
Bicarbonate solution																

POST-LAB: graph your group's data and the class average.
Graph: _____



Conclusion: Answer in complete sentences!

1. What gas is being consumed in photosynthesis? What gas is being produced in photosynthesis?

2. How do the gasses consumed and produced in photosynthesis affect the buoyancy of the leaf?

3. Possible errors:
    - What possible errors may have affected the results? (Identify at least one.)
    - How would the results be different had these errors not occurred?

4. Think about other variables that may affect the rate of photosynthesis. Choose ONE variable and describe how you would set up an experiment to test it.