Biology- Mr. Mullens Name _____

Due Date: 3-31-20

(3 PI's)

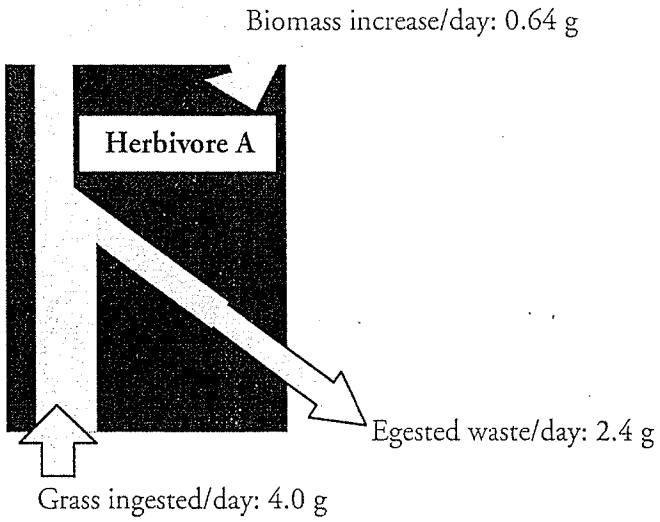
# Energy Transfer in Living Organisms

How does energy move through an organism?

## Why?

The **law of conservation of energy** states that energy can be neither created nor destroyed; it can only be transferred to another form. In living things energy is transferred as organic matter (molecules of carbohydrate, fats, starch, etc.). But does an organism use all of the energy that is provided by the organic matter available? How is the law of conservation of energy applied to living organisms?

## Model 1 – Food Conversion in a Herbivore




1. According to Model 1, how many grams of grass does herbivore A eat each day?

2. Refer to Model 1.
   *a.* How much did herbivore A grow from eating this grass?

   *b.* What term is used to represent growth in Model 1?

3. What is meant by "egested waste" as it is used in Model 1?

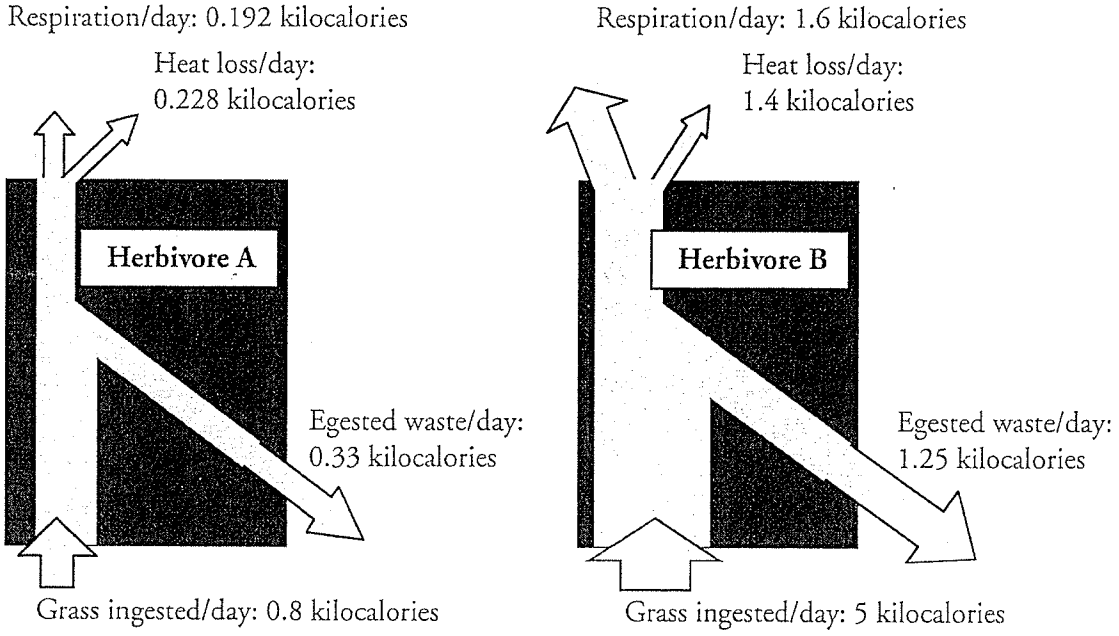
4. Is all of the mass of the ingested grass accounted for in the growth and waste of herbivore A? If not, how much is "missing"? Show a mathematical calculation to support your answer.

5. In addition to growth and waste production, what else does herbivore A's body do with the food it ingests?

6. As cells undergo cellular respiration, what products are produced, and how are they released from the body?

7. Draw an arrow in Model 1 to represent respiration and label it with the appropriate title and mass.

## Model 2 – Energy Efficiency in Two Organisms




8. What unit of energy is used in Model 2?

9. Refer to the energy value of the ingested grass in Model 2.
   *a.* What is the energy value of the grass eaten by herbivore A each day?

   *b.* What is the energy value of the grass eaten by herbivore B each day?

   *c.* Which herbivore would you predict to be the larger animal? Explain.

10. In Model 2, what are the three ways that the energy taken in by the herbivores is used?

11. For each herbivore calculate the total energy output.
    *a.* Herbivore A =
    *b.* Herbivore B =

12. Does the total amount of energy output for each herbivore add up to the total amount of energy eaten by each herbivore?

13. Use the information given in Model 1.
    *a.* What accounts for the differences noted in Question 12?

    *b.* Add labels to Model 2 to show this energy.

## Read This!

Biologists often refer to organic matter by the potential energy that is released when the substance undergoes a chemical change to make carbon dioxide and water. This could occur by burning the organic matter or by an organism using the organic matter in cellular respiration.

14. According to Model 1, herbivore A eats 4 g of grass per day. Using Model 2, how much potential energy does this represent?

15. According to Model 2, how much energy does herbivore A require for cellular respiration each day?

16. Energy lost as either heat to the environment or egested as waste is not considered to be an efficient use by the organism. What percentage of the potential energy of the grass is not efficiently used by herbivore A?

17. What percentage of the potential energy of the grass is not efficiently used by herbivore B?

18. Do the herbivores have the same efficiency in using the grass toward useful purposes? Explain in two or more complete sentences.

19. Herbivores A and B are eaten by carnivores.

    *a.* Which category of energy related to the organisms in Model 2 is directly available to the carnivore who eats the herbivores: grass, respiration, biomass or waste?

    *b.* What percentage of the original "grass energy" is available to the carnivore if it eats herbivore A?

    *c.* What percentage of the original "grass energy" is available to the carnivore if it eats herbivore B?

20. Which herbivore is the more efficient food choice for the carnivore? Why?

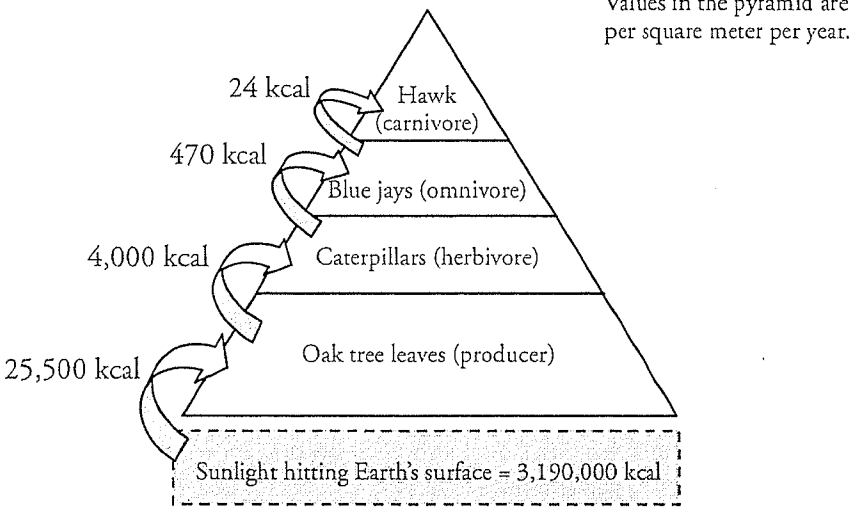
# Ecological Pyramids

How does energy flow through an ecosystem?

## Why?

Every organism in an ecosystem is either eating or being eaten. When cows eat grass, they obtain some of the energy that the grass transferred from the sunlight it absorbed. If cows could carry out photosynthesis, would they have access to more energy than they get as herbivores? Which organisms in an ecosystem require the most energy to sustain life?

## Model 1 – Pyramid of Energy




1. A unit used to measure energy is the **kcal**.
   *a.* What is the source of all energy in the pyramid in Model 1?

   *b.* How much energy does this source provide to a square meter of the Earth per year? (Be sure your answer includes units.)

2. Label the pyramid levels in Model 1 with the following: primary producers, primary consumers, secondary consumers, and tertiary consumers.
3. The arrows in Model 1 represent the energy available to the next level of the pyramid.
   *a.* What percentage of the source energy from Question 1*a* is absorbed by the oak leaves in Model 1?

   *b.* By what process do the oak leaves harness this energy?

4. Describe how the consumers in one level of the pyramid obtain energy from the organisms at the previous level of the pyramid.

5. Refer to Model 1.

   *a.* How much energy per year do the caterpillars in Model 1 obtain from eating the leaves in a square meter of the oak tree?

   *b.* What percentage of the energy that was originally absorbed by the oak leaves is passed on to the caterpillars?

   *c.* What percentage of the energy absorbed by the oak leaves is not passed on to the caterpillars?

   *d.* With your group, list at least three possible uses and/or products of the energy absorbed by the oak leaves that did not contribute to the production of biomass.

6. Calculate the percentage of energy that is transferred from one level of the pyramid in Model 1 to another for all of the levels.

   *a.* Oak leaves to caterpillars (see Question 5*b*).

   *b.* Caterpillars to blue jays.

   *c.* Blue jays to hawk.

7. Calculate the average percentage of energy that is transferred from one level to another using your answers in Question 6. Note that this average percentage transfer is similar for many different types of energy pyramids in nature.

8. As a group, write a statement that describes the pattern of energy transfer among consumers within a pyramid of energy.

9. What percentage of the caterpillars' original energy is available to the hawk?

10. What percentage of the oak leaves' original energy is available to the hawk?

11. Explain why an energy pyramid in any ecosystem typically is limited to four or five levels only.

12. Propose an explanation for why populations of top carnivores, such as hawks, are always smaller than the populations of herbivores, such as caterpillars.

## Read This!

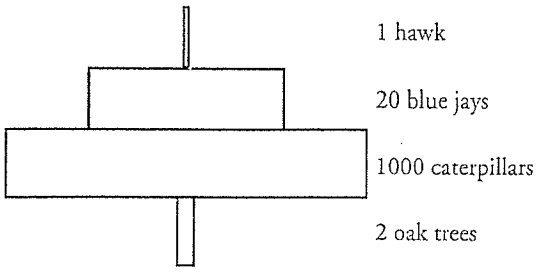
Each level in the pyramid in Model 1 is a **trophic level**. The word "trophic" refers to feeding or nutrition. Model 1 shows one example of one organism that would be included in each level, but each level in an ecosystem includes many species of organisms.

13. List at least three other species that might be found in the trophic level with the oak trees.

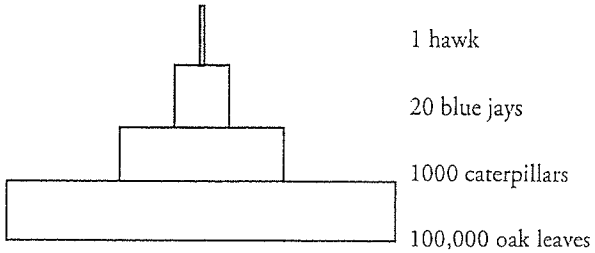
14. List at least three other species that might be found in the trophic level with the blue jays.

## Model 2 – Pyramid of Numbers

**Pyramid A**




**Pyramid B**



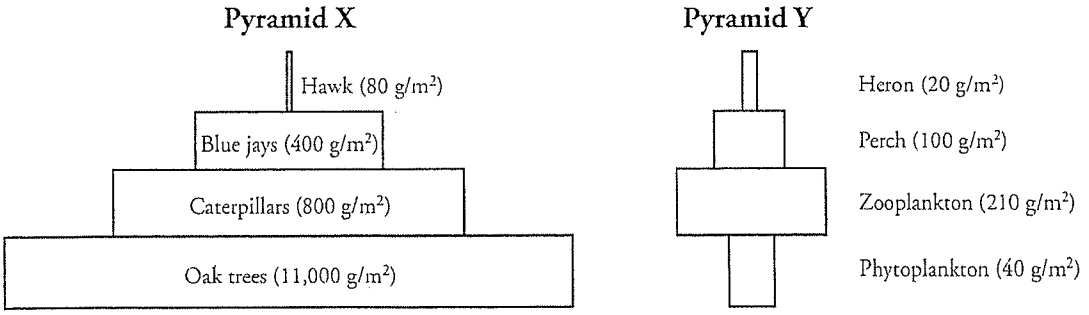

15. Compare and contrast the two pyramids in Model 2. List at least two similarities and two differences.

16. How does the number of organisms change as you move up the levels in Pyramid A compared to Pyramid B?

17. Are the "producers" levels in the two pyramids in Model 2 referring to the same organisms or different organisms? Explain.

18. Which of the two pyramids in Model 2 gives a more accurate account of what occurs in this ecosystem? Use complete sentences to explain your reasoning.

## Model 3 – Pyramid of Biomass




19. Biomass is measured as grams of dry mass within an area. What is the mass of the oak trees in Pyramid X of Model 3?

20. What is the mass of the phytoplankton in Pyramid Y of Model 3?

21. Refer to Model 3.

    *a.* Identify the trend in biomass as you move up the trophic levels in Pyramid X.

    *b.* Is the trend in biomass in Pyramid X the same as seen in Pyramid Y? Explain your answer.

## Read This!

Phytoplankton are microscopic aquatic organisms that are quickly consumed by microscopic animals (zooplankton). Because they are eaten so quickly there is a need for the phytoplankton to reproduce rapidly for survival.

22. Explain why the Pyramid Y ecosystem can exist with a smaller biomass at the producer level.

23. Use examples from the previous models to explain the advantage of using a pyramid of energy or biomass rather than a pyramid of numbers to explain the relationship between different trophic levels.

## Extension Questions

24. What type of organisms are missing from all of the trophic pyramids shown in Models 1–3?

25. Explain why a vegetarian diet is considered a more energy-efficient diet for humans than one based on beef, chicken or pork.

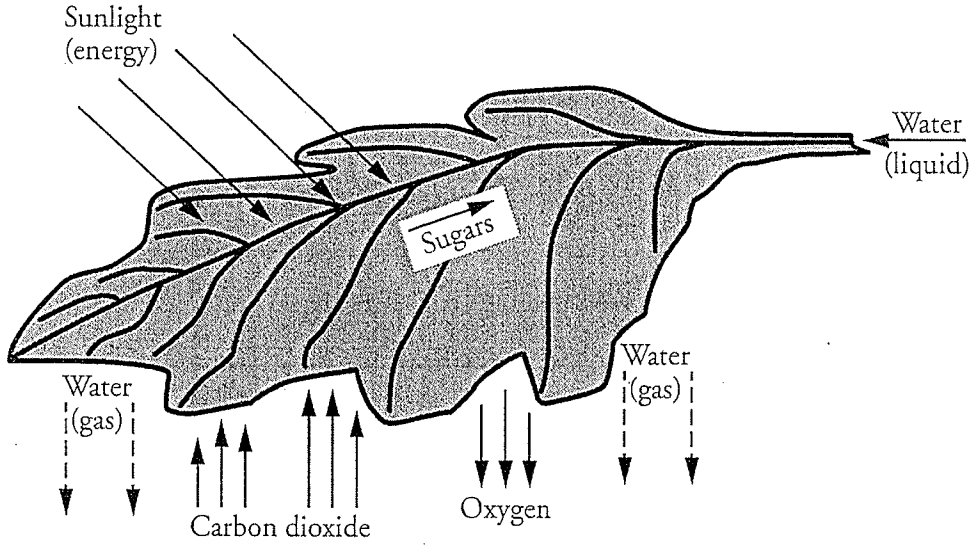
# Photosynthesis: What's in a Leaf?

What is the relationship between structure and function in a leaf?

## Why?

What would the world be like without leaves—no grass for ball fields, no beautiful landscaping? It would also mean no oxygen for animals and no food for heterotrophs. Leaves are like living machines that recycle the carbon and oxygen in our environment. This process, driven by the sun's energy, allows for a constant supply of oxygen and food for the inhabitants of Earth.

## Model 1 – Leaf Sun-Catcher




**General Equation for Photosynthesis**

$$\underset{\text{Reactants}}{\text{carbon dioxide} + \text{water}} \xrightarrow[\text{energy}]{\text{light}} \underset{\text{Products}}{\text{sugars} + \text{oxygen}}$$

1. List three things entering the leaf in Model 1.

2. List three substances leaving the leaf.

3. Which substance is both entering and leaving?

4. Veins are important structures that carry materials through the leaf. Label the central vein in the leaf diagram.

5. How is the substance you identified in Question 3 changed between its entry and its exit?

6. Use the general equation for photosynthesis and Model 1 to answer the following questions.
   *a.* What are the reactants for photosynthesis?

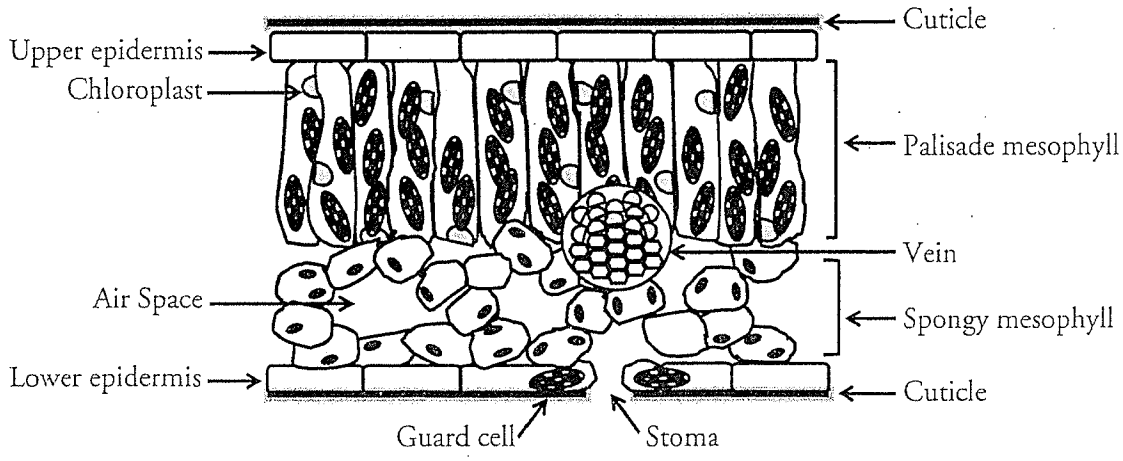
   *b.* Where do these reactants enter the leaf?

   *c.* What are the products of photosynthesis?

   *d.* From where do the products leave the leaf?

7. Categorize all the components involved in photosynthesis as either matter or energy.

## Model 2 – Cross Section of the Internal Structure of a Leaf




8. List the layers of the leaf starting at the upper cuticle all the way to the lower cuticle.

## Read This!

Inside plant veins are two different types of tissues. **Xylem** carries water and minerals up from the roots of the plant and **phloem** carries the sugars (nutrients) away from the leaf to areas where the plant is growing or to storage areas in the plant.

9. Describe the position of the vein(s) in each model.

   *a.* In the leaf in Model 1.

   *b.* Within the leaf cross section in Model 2.

10. How does the placement of veins help to carry out their function of transporting materials to and from the leaf?

11. Look back at your answers to Questions 1–3 and the photosynthesis equation. In the appropriate locations on Model 2, mark with labels and arrows what is entering the leaf and what is exiting the leaf.

12. Which kind(s) of cells have chloroplasts in them?

13. Remembering the function of chloroplasts, in which part(s) of the leaf is photosynthesis taking place?

14. The green color of chloroplasts is due to a pigment in them that absorbs light energy. Knowing this, infer which layer inside a leaf gives the whole leaf its green color. Write one complete sentence to express your reasoning.

15. Through which layer(s) does light energy travel to reach the palisade mesophyll?

16. List at least three differences between the cells of the palisade mesophyll and the cells that make up the other areas within the leaf.

17. How would the cylindrical shape of the palisade mesophyll cells increase the amount of photosynthesis that the leaf can carry out?

18. What would be the advantage(s) to having no chloroplasts in the cells of the spongy mesophyll?

19. Suppose there were many chloroplasts in the cells of the upper epidermis. How would that change the amount of sunlight reaching the chloroplasts in the palisade layer?

20. Considering its locations and your previous knowledge of the word, what do you think might be the function of the epidermis?

## Read This!

The cuticle covering the upper and lower epidermis of land plants is made of a waxy substance that repels water in much the same way as wax on a paper cup.

21. What is the purpose of having a water-tight covering?

22. Look carefully at the lower surface of the leaf in Model 2.

    *a.* What structure is found between guard cells?

    *b.* How would you describe this structure?

    *c.* How would this affect the ability of the leaf to retain water especially in dry conditions?