A KBS K-12 Partnership Activity

Into thin air:

What happens to leaves when they decompose?

Emily Grman (grmanemi@msu.edu)

OVERVIEW

Students will expand on their understanding of carbon cycling by measuring the concentration of CO_2 and O_2 in sealed containers with decomposing leaves. Students will gain experience using the Vernier LabQuest system with two gas sensors. They will also graph data and use the data to evaluate their predictions about what will happen to the carbon inside leaves.

OBJECTIVES

At the conclusion of the lesson, students will be able to:
- Understand that most of a leaf's mass goes into the air during decomposition
- Recognize the six major elements making up living tissue
- Understand why decomposition is a central step in carbon cycling.

LENGTH OF LESSON

Setup: one 60min class period
Data collection: 20 min each day, 1 day per week, 3 weeks?
Conclusion: two 60min class periods

GRADE LEVELS

8th grade

STANDARDS COVERED

B1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision)
B1.1D Identify patterns in data and relate them to theoretical models
B1.1E Describe a reason for a given conclusion using evidence from an investigation
L2.p3A Explain the significance of carbon in organic molecules (prerequisite)
L2.p3.B Explain the origins of plant mass (prerequisite)
L2.p4A Explain how an organism obtains energy from the food it consumes (prerequisite)
L2.p5A Recognize the six most common elements in organic molecules (C, H, N, O, P, S) (prerequisite)
L2.p5B Identify the most common complex molecules that make up living organisms (prerequisite)
B2.1B Compare and contrast the transformation of matter and energy during photosynthesis and respiration
B2.2B Recognize the six most common elements in organic molecules (C, H, N, O, P, S)

B2.2C Describe the composition of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids)
B2.4f Recognize and describe that both living and nonliving things are composed of compounds, which are themselves made up of elements joined by energy-containing bonds, such as those in ATP
L3.p3C Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen) (prerequisite)
B3.3b Describe environmental processes (e.g., the carbon and nitrogen cycles and their role in processing matter crucial for sustaining life

MATERIALS

Quart size ziplock bags
Topsoil
Leaf litter
Window screen, cut and sewed into bags approx 4x4"
Paper clips
Balances
Student worksheets
Vernier LabQuest, CO_2 gas sensor, O_2 gas sensor
Graph paper

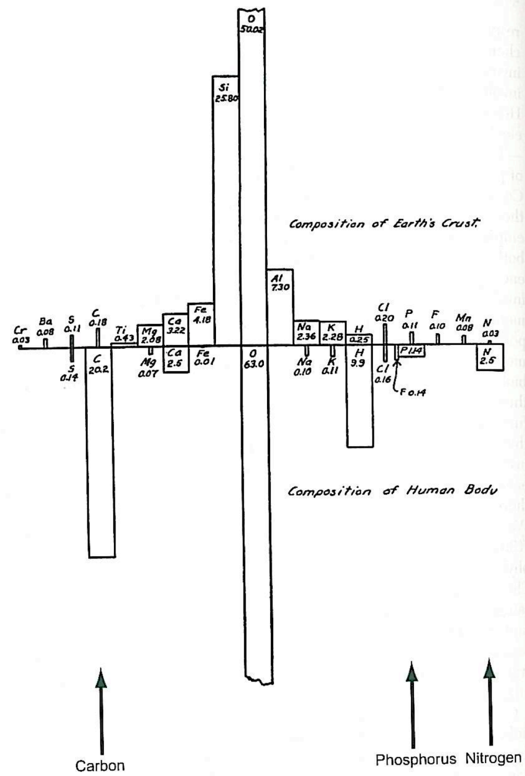

Fig. 2.1. A historical comparison of the elemental composition of the Earth's crust (upper bars) and of the human body (lower bars). The disproportionate abundance of C, N, and P in the human body is apparent (disregard oxygen and hydrogen, which dominate due to their preponderance in mineral oxides and in water). Our book considers the evolutionary and ecological ramifications of the fact that natural selection has made this highly nonrandom selection from the periodic table and from the available elements on the Earth. Based on Lotka (1925).

BACKGROUND

Ecological stoichiometry is the branch of ecology that seeks to explain how and why the elemental composition of organisms' bodies are so different from their environment. The figure (from Sterner and Elser 2002) and table (from Mauseth 1998) below summarize the general pattern of elemental abundance in the earth's crust, human bodies, and plant bodies. In general, organisms are enriched in nitrogen, phosphorus, and carbon relative to the abundance of useable forms of these elements in nature. (Remember that N_2 and CO_2, relatively abundant gases, must be turned into other compounds before they are useable.) The table in the answer key to the student worksheet explains what these nutrients are needed for. Sulfur, oxygen, and hydrogen are also essential components of living organisms, but they are rarely limiting and therefore receive little attention in the scientific literature. Carbon, nitrogen, and phosphorus cycling are all important concepts because C, N, and P are essential for life. C, N, and P cycling are all linked through decomposition.

Carbon cycles between inorganic (e.g., CO_2) and organic (e.g., $C_6H_{12}O_6$) forms. Decomposition is an essential step in this process, as are respiration and photosynthesis. Photosynthesis uses solar energy to transform CO_2 into organic forms of carbon that can be used to build tissues and store that solar energy for later use; respiration and decomposition transform organic carbon molecules into CO_2 and release the stored energy for use in cellular processes (moving, reproducing, etc).

TABLE 2.2 *Essential Elements*

Element	Symbol	Atomic Number	Atomic Weight	Amount Needed in Tissues Relative to Molybdenum
Hydrogen	H	1	1	60,000,000
Boron	B	5	10.8	2,000
Carbon	C	6	12	35,000,000
Nitrogen	N	7	14	1,000,000
Oxygen	O	8	16	30,000,000
(Sodium	Na	11	23)	
Magnesium	Mg	12	24.3	80,000
Phosphorus	P	15	31	60,000
Sulfur	S	16	32	30,000
Chlorine	Cl	17	35.4	3,000
Potassium	K	19	39.1	250,000
Calcium	Ca	20	40.1	125,000
Manganese	Mn	25	54.9	1,000
Iron	Fe	26	55.8	2,000
Cobalt	Co	27	58.9	N/A
Copper	Cu	29	63.5	100
Zinc	Zn	30	65.4	300
Molybdenum	Mo	42	95.9	1

These elements are essential for plant life; each carries out one or more vital roles. If any one is missing, a plant cannot survive. Sodium is essential for animals but not for plants. Atomic number corresponds to the number of protons in the atomic nucleus of each; atomic weight is the number of protons plus neutrons in each nucleus.

ACTIVITIES OF THE SESSION

1. Begin by finding out what students know about what plants are made of. If we zoomed all the way in on a leaf, what elements would we find?
2. Fill out the table on page 1 of the student worksheet—students will be able to guess at least O, H, P, and N from knowing what is in plant fertilizer and what is in water.
3. Where do plants get those things that their bodies are made of? (Animals get them by eating things made of those organisms—what do plants do instead of eat?)
4. Introduce the process tool by walking through a familiar process (photosynthesis).
5. Then use the process tool to explore decomposition and answer the rest of the questions in the worksheet. Pay special attention to the predictions section.
6. Move to the lab and build the experimental units:
    a. Have students fill their litterbags (mesh bags made of windowscreen) with dried leaves
    b. Make sure the students weigh their litterbags with leaves!
    c. Put the litterbags inside ziplocks and add soil and a little bit of water (soil should be good and damp but not soaking wet)
    d. Measure initial CO2 and O2 in the air inside the bags
    e. Seal the bags!
    f. Label the bags and leave them in a warm, shady area
7. Come back the next day. Being careful not to let too much air into or out of the bag, measure CO2 and O2. Have they changed at all? Record the data in the data table in the student worksheets.
8. Repeat measurements as often as needed and for as long as needed.
9. At the end of the experiment, fold open the ziplock bags and let the contents air dry (at least a week).
10. When dry, remove the litterbags and weigh them. Record the data on the student worksheet.
11. Hand out graph paper and have students graph their results.
12. Answer the discussion questions, either in small groups or as a class.

RESOURCES

Data on elemental composition of leaves taken from Table 2.2 in Mauseth, J. D. 1998. Botany: An Introduction to Plant Biology (2nd edition). Jones and Bartlett, Sudbury, MA, USA.
Data on elemental composition of the earth's crust and human bodies taken from Sterner, R. W. and Elser, J. J. 2002. Ecological Stoichiometry: The Biology of Elements from Molecules to the Biosphere. Princeton University Press, Princeton, NJ, USA.