Building and Monitoring a Living Machine

Submitted by: **Shelley F. Snyder, ssnyder@mtabe.k12.vt.us**
Topic: Wetlands Systems and the Water Cycle
Grade Level: 7-12
Content Standard: Earth and Space Science, Geochemical Cycles; Life Science, Matter, Energy and Organization in Living Systems
Content Objective: Construct a Living Machine and maintain the living machine for one semester. Explore the principles and components necessary for a healthy living machine. Learn how to monitor abiotic and biotic parameters by monitoring the living machine in class. Keep a journal for recording all observations and relate observations to lessons being learned in class.
Time Required: On going project, up to one semester
Materials Needed: See below
Directions for Instruction:

INTRODUCTION:

Wetlands systems are crucial to the renovation of surface waters. The Living Machine Unit is a series of activities and studies designed to focus the student on various parts that system. In groups, the students will build an artificial wetland in the classroom. This is a long-range study designed to allow students to discover the interrelations between flora and fauna in an ecosystem. The Living Machine will offer the opportunity to tie inter-relationships found in nature and between specific content (for information on this technology see http://www.livingmachines.com/htm/studies.htm). The students will use writing skills, math skills, and research skills to investigate the artificial wetland and relate what they learn to the world around them. The student will have an opportunity to practice standard tests used by ecologists on an artificial wetland that they design.

LESSON ASSIGNMENT

The product to be designed: Construct a Living Machine and maintain the living machine for one semester. Explore the principles and components necessary for a healthy living machine. Learn how to monitor abiotic and biotic parameters by monitoring the living machine in class. Keep a journal for recording all observations and relate observations to lessons being learned in class.

Materials needed to construct the living machines:

Aquarium	Air pumps	PVC tubing
Air	Stones	Snails

Containers (variety of sizes one gallon minimum)
Tubing (variety of sizes)
Plants from local ponds and wetlands
Goldfish or guppies

Investigation to be completed: Prove or disprove that your living machine is truly living. This will be done through observation and application of the characteristics of life.

Relationships to be Observed and Analysis: Describe the energy flow through your living machine. Look at the living machine as a system. Describe the mass and energy relationships you observe or construct in the living machine. Can you think of anything else to be observing? This thing is a machine. What does it do? How would you modify your system? Each day in class take 10 minutes to monitor the following parameters: dissolved oxygen, conductivity, ortho-phosphorous, pH, suspended solids and temperature for each tank.

Extensions: After the living machines have been established and baseline data has been collected, they can be fed food scraps. Continue to monitor all parameters during the recovery time for the system.

PROCEDURE

Day 1: Give students a variety of materials necessary to construct the living machine. This will take a full class period. Student goal should be to have water circulating through three tanks.

Day 2: Have students include one tank with soil, one producer tank and one consumer tank. They should bring biotic materials from home (or the local wetland) to introduce into the living machine during the second class. Students should read about the structure and functioning of wetlands and visit the "Living Machine Technologies" site in South Burlington VT, if possible (http://www.livingmachines.com/htm/study1.htm). Once the living machines are set up, baseline information will be collected for guppy population, pH, dissolved oxygen, and turbidity. After baseline information has been developed, students will manipulate input (turbidity in the form of pureed vegetable matter) into the swamp and continue to monitor. They will search for cause and effect relationships in their data.

Each day from this point, have the students monitor for chemical parameters.

Possibilities:

Hunt and observe for life with a microscope.

You may want to introduce stocks and flows (Stella, modeling program) as a way of tracing movement of water and nutrients through the tanks.

Students will read and discuss John Todd paper describing living machines and necessary characteristics. (Living Machines: Theoretical Foundations and Design Precepts,)

After the discussion of characteristics of life, students will design and build their own living machines. They will perform and design tests to determine if the swamp is alive and if the swamp is healthy. Students will be encouraged to consider those characteristics when they continue to design and modify their living machines.

Students will keep journals recording changes observed and made to the living machines. Students will analyze and report on the following as they relate to their living machines:

Structure and function of wetlands
Nitrogen cycle
Phosphorous cycle
Carbon cycle
Energy flow in living things, energy pyramids
Characteristics of life

Introduce Second law of Thermodynamics. Student Question: Is chaos increasing or decreasing in a healthy system? In your living machine?

Have a discussion about harvesting both with and without replacing or returning materials and conservation of materials. Relate to space travel.

Student Question: How does this relate to the bigger picture, planet earth? Design a test to prove your hypothesis.

VERMONT FRAMEWORK OF STANDARDS AND LEARNING OPPORTUNITIES

Vital Results

1.4 Reading range of text; students will be asked to gather information from a variety of sources including the Internet, library resources, interviews, videos, and others as they become available.

1.5 Writing draft and revise; students will write reports and produce poster sessions with rough drafts and final drafts produced.

1.10 Written procedures; students will be asked to explain procedures that they followed in testing and designing.

1.22 Employ simulations; students will use the simulated wetland to help to understand larger systems.

2.4 d Make changes and monitor their effects over time.

3.10 Teamwork; students will be asked to design and report information in teams.

Field of Knowledge

7.1 Scientific method to describe, investigate and explain; students will be asked to use the scientific method to design, investigate and explain the artificial wetlands.

7.2 Design and conduct own investigation and projects; students will be asked to design their own methods of monitoring the health of the wetlands available as well as conduct the 'standard' tests.

7.3 Understand the nature of math, science and technological theory; students will be asked to mathematically model the flow rates and changes in chemical characteristic in the wetland and why those changes occur.

7.5 Analyze roles and responsibilities; students will be asked to participate in a mock-town meeting to determine type of sewage treatment plant to be installed in their "town."

7.11 Analyze and understand living systems; students will be asked to analyze and understand the systems established in the artificial wetlands and apply that understanding to a natural wetland.

7.13 Understand characteristics of living organisms and recognize interdependence; students will be asked to identify organisms using dichotomous keys based on characteristics and study the interdependence between those species.

7.15 Identify, record, model and explain evidence of change over time (ecological system) monitor the change as the living machine adapts and after food wastes are added to the system.

7.19 Use technology and engineering processes to design solutions to problems; students will be asked to design their own lap top wetlands and maintain them through the semester.

ASSESSMENT

Students write a report detailing their living machine and comparing it to others in the room.

LIVING MACHINE REPORT

This is one of your final exam questions; you will put together this assignment and turn it in the day of the final exam. You have been keeping a record of your observations and conversations about your living machine.
Use your journal and consult with your colleagues. Each of you will write your own Living Machine report.

1. Introduction: What is a living machine? What are the components? What practical application of living machine technology exists? HINT: You might include a description of the living machine you visited in South Burlington.

2. Design and Materials: What materials did you use and why? Discuss the pros and cons of the materials you used. Include a schematic drawing including direction of water flow. How do you know when you are successful in constructing a living machine? What did you use to stock your living machine.

3. Question or Investigation: I asked you to find a question inspired by your LM that you could investigate. State your question and how you chose to investigate it. Give a detailed description of your procedure and what you learned.

4. Chemistry: You monitored the following: Conductivity, pH, ortho-phosphates, color, and odor. What did you observe? Describe any trends or relationships recorded in your data.

5. Results and Discussion: You kept a record of living things that you found in your living machine. What did you find? Draw and identify if possible. In what ways did you observe the characteristics of life? Discuss how the living machine is like an organism, including organization (hint: cells). How does your living machine reflect a larger ecosystem (biotic and abiotic factors) such as a wetland?

6. Conclusion: Is your living machine alive? Include a discussion of your definition of "living." Support your position by citing specific examples from your research.

7. Bibliography: Include any sources other than your journal in this section.

CONCLUSIONS

After the classroom living machine is completed, it will be referred to through out the semester as occasion arises. For example when energy flow through systems and food webs are studied. Students become engaged in doing scientific study. They relate concepts that they are learning in class to their living machines, and learn to work and depend on other members of the group.

CREDITS AND REFERENCES

Living Machine Technologies, Bartletts Bay Road, South Burlington, Vermont, (802) 865-4460. Tours of the Living Machine.

Ocean Arks International 176 Battery Street, Burlington, Vermont, (802) 860-0011

A partial listing of reading assignments related to water studies that students will be expected to read:

Dates, Geoff. *Below the Flow: Vermont River Communities, and How We Can Protect Them.* Vermont Environmental Report. Vermont Natural Resources Council. Winter 1990-1991. Pp 14-19.

Todd, John, and Beth Josephson. *Living Machine: Theoretical Foundations and Design Precepts. Annals of Earth*. Vol XII, Number 1, 1994. Pp 16 - 25.

Wiley, John P. Jr. *Wastewater Problem? Just plant a marsh*. Smithsonian. July 1997. PP. 24-25.

Reducing Phosphorus in Lake Champlain. Out of the Blue. Fall/Winter 1996-7, No. 13.

Henzel, Linda. Erosion, *Land Use, and Stream Ecology For Lake Champlain Basin Communities.* Pp 4 - 27

Water Water Everywhere, Hach Chemical Company curriculum.

LESSON PLAN AUTHOR & CONTACT INFO:
Shelley F. Snyder
ssnyder@mtabe.k12.vt.us
Mt. Abraham Union High School
7 Airport Drive
Bristol, Vermont 05443