

BLASTing Through the Barriers of Inquiry Learning

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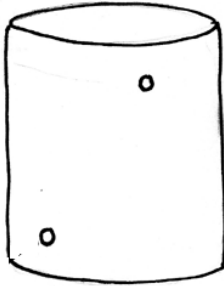
Harper Creek High School

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Building the Living Machine

Materials

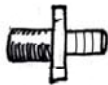


3 – 5-gallon water bottles with lids cut off (like the ones used in water coolers); cut offset holes as shown to fit the hose barbs below

1 – lid from 5-gallon



water bottle



6 – hose barbs, ½ in x ½ in



3 – 18 inch lengths of flexible plastic tubing,
5/8 OD x ½ in ID



1 – aquarium bubbler with small flexible plastic tubing



1 – tube of silicone caulk (\$3.50)

Tools needed include: Pliers, drill, variable drill bit (called an Irwin unibit, ¼ in to 7/8 in, to cut fiberglass (\$30)

Instructions for Assembly

- 1) Apply ample silicon, and screw the threaded part of the plastic plumbing hose barb into the hole drilled into the 5-gallon water bottle (sometimes slightly forceful pushing is necessary rather than threading). Make sure there is an O ring on either side of the container.
- 2) Once the barb is in place, add additional silicon where the fitting meets the water jug (both inner and outer). Secure the barb by screwing the locknut onto the threaded end of the barb.
- 3) Repeat steps 1 and 2 for all 6 holes in the water bottles.
- 4) Push the large flexible plastic tubing over the outer part of one of the lower barbs and attach the other end to the upper barb on another water jug
- 5) Repeat step 4 for all three pieces of plastic tubing, ensuring that each water bottle is connected from bottom of one to top of the other
- 6) Place lid from water bottle into one of the bottles (upside down)
- 7) Run the bubbler hose into one of the bottles, and snake up through the bottom fitting until the bubbler hose is about half way up the larger tubing
- 8) Fill all three water bottles with water, stopping just short of the tallest port
- 9) Turn on the bubbler, add water until system starts flowing, and check for leaks
- 10) Add soil and plants to the upside down lid
- 11) Add floating plants to the next reservoir
- 12) The third reservoir can hold fish and other critters, but allow the system to equilibrate for a few days before adding

Sketch of operational living machine



Materials List for Living Machines (updated 3/09)

1/2" conduit locknut, stainless steel	20/bag	\$2.33 at Lowe's
	5/bag	\$0.90 at Menards
#14 O-ring	10/pak each	\$1.97 at Lowe's \$0.47 at Menards
1/2" hose barb	each each	\$1.42 at Lowe's \$1.09 at Menards
Vinyl Tubing 5/8"OD x 1/2ID	20ft	\$7.76 at Lowe's
Aerator Tubing 1/4" OD	\$0.14/ft	Lowe's
Aerator (Whisper 20 by Tetra)	each	\$10 at Petsmart

Supplies for one Living Machine	
6 locknuts	\$0 .72
12 O- Rings	\$2.40
6 Hose barb	\$6.54
4.5 feet vinyl tubing	\$1.75
Aerator tubing	\$0.28
Aquarium aerator	\$10.00
TOTAL COST	\$21.69

Instructions for Using the Task Board

Working in a group requires many life skills. Some of the life skills we will focus on for our living machine activity are cooperation, problem solving, and organization.

Cooperation is the ability to work together toward a common goal or purpose. Our goal is to collect data daily on the living machine experiment.

Problem solving is the ability to create a solution to difficult situations and everyday problems. Our situation is that we must be able to carry out the daily routine of data collection for the Living Machine Project in an organized and efficient manner. We must anticipate group members being absent and cover for them. We must also be aware of tasks that cannot be done at the same time. Example: you can not feed the fish and mass the fish at the same time.

Organization is to plan, arrange, and implement in an orderly way. Since there are many tasks, each group member must be aware of what the other is doing. Planning up front will save us time and will avoid confusion.

You will use a tool to help you incorporate these life skills into the project. We will call it a task board.

Group use of task board:

Step 1: Identify and make a list of all of the tasks that will be completed on the living machine.

Step 2: Assign a time required to do each task rounding to the nearest 5 minutes.

Step 3: Cut a strip of paper for each task. The length of the paper will reflect the time needed for the task. (let one inch represent 5 minutes.) Attach each strip to a magnet.

Step 4: Cut a strip of paper and write your name on it. Attach each name strip to a magnet. Place each group member's name in a column down the left side of the task board.

Step 5: Assign tasks so that...

- a. each group member gets done at the same time.
- b. there are no scheduling conflicts.
- c. it does not interfere with the lab protocol.

Step 6: Practice rearranging the Task board assuming a group member is absent.

Poster Assignment for Living Machine Experiment

The goal of a poster is to convey information about a scientific experiment to other scientists or to the public. For our class, we will assume that our audience is other scientists at a similar level of expertise (you can imagine your audience to be another Physical Sciences class). The poster will be worth a total of 50 points. Points will be awarded according to the following breakdown:

For all sections, you will be graded for content, clarity, and graphical organization. Use of figures and pictures is highly recommended as it can greatly increase the visual impact of your poster.

Introduction (10 points): You may either 1) Choose the best introduction written by one of your group members, or 2) Combine the best parts of multiple introductions written by your group. Remember, an ideal introduction has the following characteristics:

- 1) It explains to the reader why the experiment was done (What is your question, and why is it interesting?).
- 2) It provides background information that allows the reader to understand the question and system used.
- 3) It provides a brief experimental setup and rationale for using that setup.
- 4) It explicitly states the hypotheses of the experiment (this could be a sub-section)
- 5) It is concise. You have to strike a balance between including every possible detail and being too brief. Include the most relevant information and leave out unimportant facts. You have to inform your reader, but you can't bore them!

Materials and Methods (10 points): An ideal materials and methods section should have the following characteristics:

- 1) It provides the reader sufficient detail that they could perform the experiment without additional guidance.
- 2) It effectively uses pictures and diagrams to illustrate the ideas presented.
- 3) It is arranged in an orderly, logical, and visually appealing manner.

Results (10 points): A results section should convey the data that was collected during the experiment. It should contain the following:

- 1) Figures that graphically represent the data collected- These figures need to be orderly, well-labeled, and give the reader a quick understanding of what occurred in your experiment.
- 2) Tables- Optionally, you can also present your data in the form of a table. This could be done in combination (not instead of) figures.
- 3) It is arranged in an orderly, logical, and visually appealing manner.

Conclusions (5 points): A conclusions section should relate the findings to the reader in light of the original hypotheses presented. Questions to answer in this section include:

- 1) Did your results support or refute your hypotheses? Why, or why not?
- 2) What additional experiments might you perform in order to confirm or reject your conclusions?

Acknowledgements (2.5 points): You should thank the people and institutions that made your work possible.

Literature Cited (2.5 points): Any resources used to explain any part of the poster (such as articles) should be cited within the text, and there should be a complete list of these articles somewhere on the poster.

Overall Flow & Clarity (5 points): The placement of text and figures on your poster should be done in a way that achieves maximum flow & clarity. A reader should find it easy to tell where one section ends and another begins. The poster as a whole should be visually appealing as well as informative.

Peer Judging (5 points): Once completed, we will be holding a “poster session” in which students will judge each other’s posters. Each student will be asked to judge at least 2 other group’s posters. Judges will be asked a series of questions about their opinion of the poster’s (based on overall quality of presentation, information provided, logic of layout, graphical appeal, etc.). Points will be awarded based upon these responses.

Example of Standards Integration

- 40% of the Michigan Merit Exam is based on the Scientific Inquiry and Scientific Reflection and Social Implications benchmarks.
- Current methods of integrating long term research projects into the Physical Science curriculum allows students to become proficient in these often difficult to practice benchmarks.

Content benchmarks are incorporated into the projects. For example, the following benchmarks are taught as an integral part of our Pollution Experiment.

Benchmark	Description	Connection in Experiment
E 2.3b	Explain why small amounts of some chemical forms may be beneficial for life but are poisonous in large quantities.	Modeling contamination of a river
E 2.3 c	Explain how the nitrogen cycle is a part of the Earth system.	Modeling a fertilizer runoff scenario
C3.4g	Explain why gases are less soluble in warm water than in cold water	Dissolved Oxygen
C4.3d	Compare the strength of forces of attraction between molecules of different elements	Dissolved Oxygen Nitrates
C4.3f	Identify the elements necessary for hydrogen bonding	Water molecule
C4.4b	Identify if a molecule is polar or nonpolar given a structural formula for the compound	Solubility in water. Turbidity and total dissolved solids.
C5.2 A	Balance simple chemical equations	Photosynthesis; respiration
C5.2B	Distinguish between physical and chemical changes	solubility of ions in water as compared with chemical reaction such as respiration.
C5.2C	Draw pictures to distinguish the relationships between atoms in physical and chemical changes	Comparing physical and chemical processes in the experiment.

Life Skills Strategies to Overcome Typical Barriers

Barrier	Life Skill	Definition	Strategy
Students lack the background knowledge to ask a good research question; Students do not take ownership of the project	Curiosity	“ A desire to investigate and seek understanding of one’s world”	Provide experiences that develop students’ background knowledge
Disorganized lab structure leads to misbehavior; student frustration with keeping track of notes and data	Organization	“ To plan, arrange and implement in an orderly way”	Provide order to all aspects of the experiment
Students have a hard time working together	Cooperation	“ To work together toward a common goal or purpose”	Make teamwork a necessity
Students lack interest in the project; Students do not take ownership of the project	Problem Solving	“To create solutions to difficult situations and everyday problems”	Let students know that they have permission to solve problems