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FOOD SHED LESSON PLAN – CLOSED LOOP SYSTEMS

INTRODUCTION

Topic/Unit of Study: Closing the Loop

Age group: 8 – 12 years

Lesson Objective(s)

- To observe how waste from one organism or process is the fuel for another
- To understand how waste can be reused in closed loops systems for better sustainability
- To synthesize understanding by designing a closed loop

Materials

Fish feed

Gardening implements

Sample of aquaponics water

with plant growing in it for 2 weeks prior

Pencil & paper

Small pot with vermicompost & seedling

Rapid aquarium nutrient test kits for measuring nitrate

Key terms

Waste

Resource

Loop

Positive interaction

Attachments (depend on the activity)

- PDF of sheet to draw closed-loop system, with prompts for what to include.
- Handout of the Food Biome Loop diagram



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CONTENT TIME

Identify (~5 min)

- Since the 1950s, a number of changes – such as rising greenhouse gases and shrinking reserves of clean water – have occurred on the planet. This so-called “Great Acceleration” points to a breakdown of sustainability.
- Up to this point, the Earth has sustained life with the input of only sunlight for 3.5 billion years. This makes it a closed loop system - akin to a sealed bottle – where water, gases and other chemical elements are recycled and regenerated continually over short and long periods of time.
- Ask students if they can imagine humans being as efficient at reusing waste as the Earth system
- Actually, closed loops of varying types and degrees are all around us. Can students think of any?

Examples include:

- o Some isolated ecosystems like ponds that recycle a lot of their nutrients to support plants and animals season after season
- o Life support systems being developed for space will one day enable long-term travel to other planets
- o Some farms, called integrated farms, that recycle waste from plants and animals in a tightly closed loop to minimize the need for inputs like fertilizers. An example is ancient Chinese agriculture that grew rice, fish, mulberry trees, and silkworms together in a harmonious balance. Scientists find that modern equivalents of these farms in India – are up to three times more sustainable and twice as profitable as farms growing crops without animals to help recycle waste.
- Some questions to consider:
 - o How does an integrated farm recycle different forms of waste?
 - o How might recycling waste in closed loops help the planet in terms of sustainability?

Understand (~10 min)

- The Food Biome is an unusual type of farm because it grows plants and animals of many kinds in a small indoor space.
- It is a partially closed loop because the waste produced inside the farm is recycled.
- The key to a closed loop is that waste produced in one part of, say, a farm can be used as a resource in another part of it.
- There's an expression that one person's trash is another person's treasure, and this is true for many combinations of plants, animals and processes in a closed loop system like the Food Biome.



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- When “trash” from one organism or process, say on a farm, can be used as “fuel” for another, it is a form of what’s called a positive interaction. Waste from one plant or animal becomes a beneficial resource for another.
- When there are many of these positive interactions, waste from one organism can easily be used by another and everyone’s trash becomes everyone else’s treasure
- An interesting example: Closed loops for space travel involve the idea that all waste from astronauts – CO₂, urine and feces – can be transformed by a range of plants, animals and microbes back into the stuff of life, such as oxygen, water and food.
- One of the most advanced of these is the MELiSSA Loop being developed by the European Space Agency. It takes inspiration from wetlands for how different plants and microbes can use each other’s waste to keep the living environment clean, recycle precious oxygen and water, and produce food (see Resources).

Process - instruction for experiment/activity (15 – 25 min)

1. Invite students into the indoor farm or show them props such as miniature tanks if off-site.
2. Have students feed the fish with pellets. Ask students what they think will happen once the fish digest the food? What happens to the waste in a fish tank? (Hint: it decomposes and becomes dissolved as nutrients).
3. Have students look at the aquaponic plants, including their roots. Ask students what resources these plants use to grow? (Hint: plants take up dissolved nutrients from the water).
4. Measure nitrate levels in the aquaponics unit. Compare it to a pre-prepared vessel of isolated aquaponics water with a plant growing in it. Lower levels here than in the main water reflect nutrients being taken up the plants.
5. Have students trim plants. Ask students where the crop residues go next? (Hint: crop waste is broken down in the worm bin).
6. Show students the worm bin. What goes into the worm bin and from where? Ask students what they think the vermicompost can be used for.
7. Give each student a pot with vermicompost and a seedling to take home to start a new garden.
8. Have students top up the algae bioreactor or duckweed module with aquaponic water (or worm bin leachate for the algae bioreactor, not the duckweed module). Ask students what they think will happen to the nutrients in the water?
9. Measure nitrate levels in the algae bioreactor and compare it to the bioreactor’s source water (aquaponics unit or worm bin leachate). Lower levels of nitrate reflect nutrients being taken up by the algae.

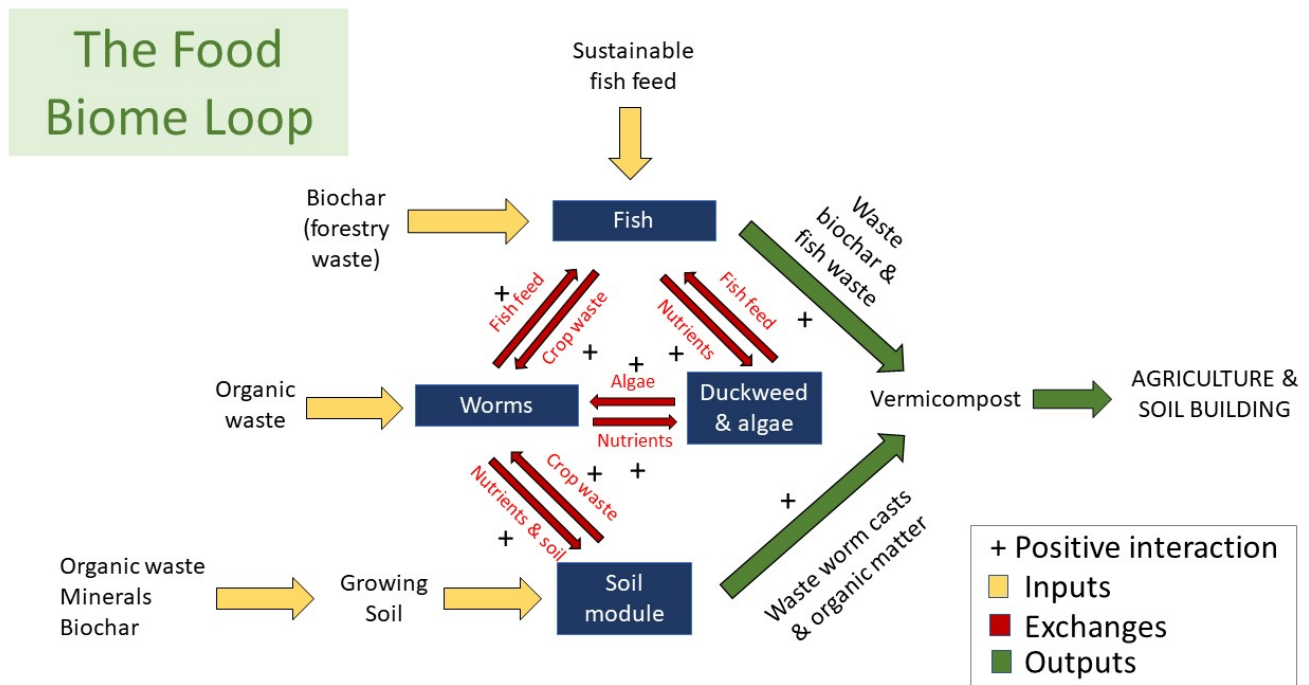


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CLOSING

Analyze and Communicate (~15 min)

- Ask students to make a quick diagram of the parts of the Food Biome, such as the aquaponics tanks and worm bin. They can draw arrows where waste from one system or organism is a resource for another. They can mark these with a '+' for positive.
- Students will probably all hone in on fish waste becoming nutrients for plants or duckweed become food for a fish. Ask students if they can think of benefits beyond waste becoming food? You can point out that too many nutrients in the water are unhealthy for fish and so plants removing these nutrients cleans the water for fish. This is a more subtle type of positive interaction where one organism improves the environment for another.
- Ask students to compare their diagrams and share what stood out most to them and why they drew it as they did.
- The diagram below shows many of the positive interactions that exist in the semi-closed loop of the Food Biome. Student diagrams will only capture a few of these links, so sharing their insights in the Conclude section is important to broaden the perspective.
- The diagram may be shown at the end of the discussion to see how interactions and loops can be mapped.





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Conclude (~5 min)

- Ask students again whether they think humans can be efficient like the Earth system in turning waste into opportunity
- Ask them what kinds of waste they will see differently now as resources. Some possible examples include: Food waste, garden waste, construction waste etc.
- What are some of their thoughts for how to transform waste into resources for humans and the planet?

RESOURCES

The MELiSSA Loop of the European Space Agency:

http://www.esa.int/Enabling_Support/Space_Engineering_Technology/Melissa/Closed_Loop_Compartments

REFERENCES

Kumar S, Subash N, Shivani Singh S and A Dey. 2021. Evaluation of different components under integrated farm system (IFS) for small and marginal farmers under semi-humid climatic environment. *Experimental Agriculture*. 48(3): 1 – 15.