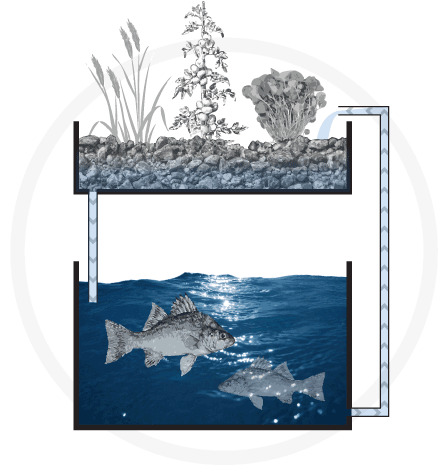
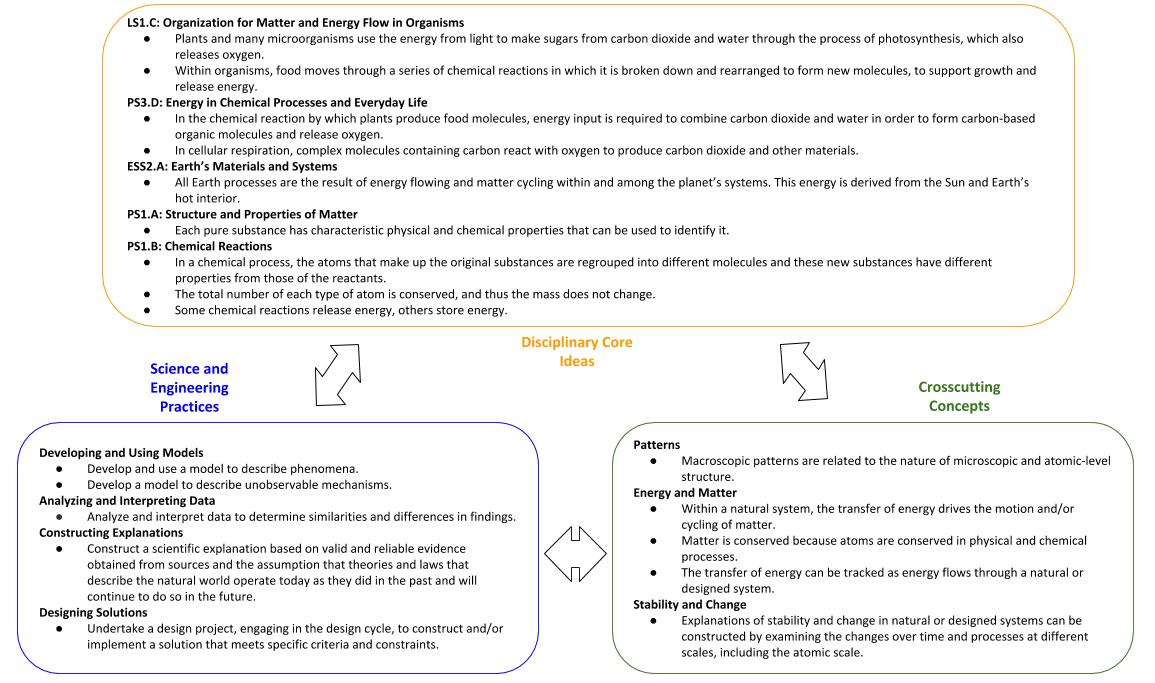
**Unit Essential Question:** *How does energy and matter flow within natural and designed systems?*

**Introduction**

Real ecosystems, like the river environment students saw in the Lift-Off, have natural cycles that keep them functioning and healthy all on their own. By studying real ecosystems, we can learn how to replicate these cycles in artificial environments of our own making. Aquaponics systems, like the one shown to the right, use our understanding of real ecosystems to create an environment that sustains itself. Matter and energy flow within and between the garden on top and the fish tank below, providing each environment with the factors it needs to thrive.

For this unit’s project, each group’s task is to use what they learn about how energy and matter flow through ecosystems in order to design and build a sustainable aquaponics system that mimics the properties of a river environment. Individually, students will then write an instruction manual that describes their aquaponics system and explains the science behind how it functions.

**3-Dimensional Assessment**

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**Time Needed (Based on 45-Minute Periods)**

7 Days at end of unit

* Group Project: 3 periods
* Individual Project: 4 periods
  + First draft: 2 periods
  + Feedback: 1 period
  + Revision: 1 period

**Materials**

Option A - Group Aquaponics System: Because it is very expensive to provide materials for every group to make a true aquaponics system, students will use a combination of recycled and household materials to make a cheaper version.

* 2 large soda bottles
* String (acts as “water pump” to bring water from fish tank up to soil)
* Gravel
* Growing medium (pea gravel, perlite, peat moss, etc)
* De-chlorinated water
* Fish
* Plants
* Other organisms (based on student choice)
* Scissors
* Electrical Tape
* Materials from Task 5 for heating devices (See Task 5 Teacher Version)

Option B - Class-wide Aquaponics System: You may choose to gather these materials on your own or purchase an aquaponics “kit,” available online or in large hardware stores. Search for aquaponics system building instructions online for more details.

* Glass or plastic tank for the fish (3-20 gallon recommended)
* Gravel (2.5 lbs per 5 gallons of water in fish tank)
* Small circulation or fountain water pump (3-4 watt) to pump water from fish tank to grow bed
* Grow bed (must be able to sit on top of fish tank, 3-8 inches deep, with holes to drain into fish tank)
* Growing medium (pea gravel, perlite, peat moss, etc)
* Aquarium air pump
* De-chlorinated water
* Fish
* Plants
* Other organisms (based on student choice)
* Optional:
  + Plastic tubing
  + Supports for grow bed, if necessary
* Scissors
* Electrical Tape
* Drill
* Materials from Task 5 for heating devices (See Task 5 Teacher Version)

Instruction Manual

* Optional: Instruction Manual Template
* Blank Paper for final draft
* Optional: Colored pencils or markers

**Instructions for the Culminating Project**

1. Introduce the Culminating Project at the end of the Lift-Off task, including both group and individual components outlined in the Challenge.
2. Read over the Culminating Project Task Card with the students. We recommend only reading the Challenge and Group Project Criteria for Success at this time in order to not overwhelm students with information.
   * Take questions for clarification.
   * Optional: Show the following video to introduce students to aquaponics: <https://www.youtube.com/watch?v=n-SXRtNoEkI>
   * We highly recommend showing a few examples of different types of aquaponics systems so students get a general idea of what they look like. There are many examples online, but this student manual has some good diagrams on pg 10 and 12: <http://northhuronag.weebly.com/uploads/1/1/2/8/11286496/aquaponics_curriculum_student_manual.unlocked.pdf>. You will likely need to remind students of the structure of an aquaponics system for the first few tasks of this unit.
   * Provide students with a list of relevant materials they will have available to build, as this will impact their system design for the rest of the unit.
3. Remind students that as they go through the Project Organizer, they will be planning parts of their aquaponics system and recording information they may need for their individual project. However, there is nothing wrong with going back and changing their ideas over the course of the unit. The students won’t fully design their system until the end of the unit, so change is acceptable and often experienced.
4. Make sure students fill out the Project Organizer after each task, which will help them think about the science behind their aquaponics system along the way. This process allows students to both apply and document relevant scientific concepts as they move throughout the unit. This will inform both their group and individual projects.
   * We recommend that students complete the Project Organizer individually. They might discuss ideas first as a group, but should then respond individually. This allows students time to process concepts on their own and generate their own ideas, which can be used later when it comes to developing their group project.
5. The table below summarizes how the Project Organizer guides students through developing different components of their aquaponics system and instruction manual.

|  |  |  |
| --- | --- | --- |
| **Task** | **Project Organizer** | **Group and Individual Culminating Project** |
| **Lift Off**  Changing Rivers | * What did you see in the pictures that you might also want to include in your aquaponics system (garden and tank)? | * Aquaponics system includes essential living and non-living parts of an ecosystem * Instruction manual contains a diagram that includes and labels all living and non-living parts |
| **Task 1**  Types of Changes | * Draw a before and after picture of your aquaponics system for each physical and chemical change, writing a caption explaining each. * What data explains how you know what type of change it is? * Do the changes represent a threat to your aquaponics system? If so, what are some potential solutions? | * Instruction manual identifies and explains one physical and one chemical change that occurs in the aquaponics system, using data to explain how macroscopic properties allow them to determine the type of change |
| **Task 2**  Matter Moves You | * What organisms in your aquaponics system do cellular respiration? * What molecules are used and created in this process? How will the system provide these reactants and use up these products? * Draw a model of cellular respiration. | * Aquaponics system includes an organism that does cellular respiration * Instruction manual models and explains cellular respiration, including how matter is conserved in this process |
| **Task 3**  Cycling Matter Through Living Things | * What organisms in your aquaponics system do photosynthesis? * What molecules are used and created in this process? How will the system provide these reactants and use up these products? * Draw a model of photosynthesis. * How do the plant and animal (from Task 2) work together to cycle matter and keep energy flowing through the system? | * Aquaponics system includes an organism that does photosynthesis * Instruction manual models and explains photosynthesis, including how energy drives the cycling of matter in this process |
| **Task 4**  Cycling Matter Through Rocks | * How is matter cycled in the system? * Which processes of the rock cycle might occur over time in your aquaponics system and how would this affect the system? | * Instruction manual models and describes the processes of the rock cycle that might occur in the aquaponics system over time, including why other rock cycle processes are not identified |
| **Task 5**  Design a Thermal Device | * Draw the final heat-regulation device you will use to maintain the temperature of the fish tank. * Label the materials used and explain how it works. | * Aquaponics system includes a heat-regulation device to maintain the temperature of the fish tank * Instruction manual contains a diagram that shows and explains how the heat-regulation device works, including the design process that led to the final product |

1. After all the learning tasks are completed, and all sections of the Project Organizer are completed, the students can start to design their aquaponics system. The Project Organizer and Group Project Criteria for Success should be used as reference for the students to remind them of all parts to include in their system.

* We recommend the use of group roles for Culminating Project work time (See “How to Use This Curriculum” document for details). We recommend changing the roles every workday.

1. As shown in the materials section, you have two options for completion of the Group Culminating Project.

* Option A: Have students use the cheaper materials list to make Biobottle Aquaponics Systems in groups. Note: These may not function as well or be as long-lasting as the option below.
* Option B: Because building aquaponics systems are material and time-intensive, we offer the option of students designing their aquaponics system as a visual poster model. All of the group posters would then be used to inform a class-wide build of one aquaponics system. After creating consensus, we recommend assigning each group part of the aquaponics system to build.
* For more information on aquaponics systems, the following websites might be helpful:
  + <https://aquaponics.com/build-a-mini-aquaponic-system/>
  + <http://www.homesteadandprepper.com/diy-aquaponics-projects-for-beginners/>
  + https://besurvival.com/tips-and-tricks/diy-beginner-aquaponics-projects

1. Optional: If using Option A, after students have built their aquaponics systems, conduct a gallery walk so students can observe other groups’ designs.

* For a more interactive gallery walk, give each student a few post-its that they must write positive or constructive comments on to leave at various groups’ tables.

1. Once the aquaponics systems are built, students are ready to move on to their individual project. Students will create an instruction manual that models and explains all the parts of their aquaponics system and meets all the criteria in the student handout.
   * We recommend providing a template to help them organize their instruction manual. This only provides them with a structure, so this should be used in conjunction with the Individual Project Criteria for Success checklist to ensure students include all parts required. An option is provided at the end of this teacher guide.
2. Conduct a peer review of the instruction manuals after students have completed a first draft.

* Copy the Instruction Manual Peer Review Feedback form found in the Student Instructions. Another option is to use the Student 3-Dimensional Individual Project Rubric.
* Assign each student a partner, preferably a partner from a different group.
* Students switch drafts and assess them using the peer review feedback form.
  + Remind each student to give one positive comment and one constructive comment for each section on the checklist.
  + Allow students time to present their feedback to their partner, so their partner may ask clarifying questions if needed.

1. After receiving feedback, allow students time to complete a final draft based on the feedback they received.

**Assessment**

The Project Organizer can be formatively assessed using:

* *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix from the Unit Overview to inform your criteria.

The Group Culminating Project will be summatively assessed using:

* The *Group Project Criteria for Success* Checklist

The Individual Culminating Project will be summatively assessed using:

* The *3-Dimensional Individual Project Rubric*.
* Keep in mind that the Proficient level indicates that the student has successfully demonstrated understanding of the criteria. Because we are in the early stages of NGSS adoption, it may take multiple opportunities throughout the course of the year for students to reach Proficient.
* If you wish to give students a numeric score, you could take the average score of all of their rubrics or add up rubric scores to give students a summation out of the total. Because of the note above, this scoring may not correlate to traditional grading systems.
* While we recommend scoring all of the project criteria with the rubrics for each student, we understand the burden of that level of scoring.
  + One option is to select the rubrics that you wish to focus on for this project and use those to assess each student’s individual project.
  + Another option is to review the Proficient level of each of the project’s rubrics and use the descriptions to generally analyze all student work for trends.

**Aquaponics System Instruction Manual Template**

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| --- |
| **Title** |
| **Introduction to Manual** |

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| --- |
| **Diagram of Aquaponics System** |

|  |  |
| --- | --- |
| **How Aquaponics Systems Sustain Themselves** | |
| Cellular Respiration | Photosynthesis |

|  |  |
| --- | --- |
| **Possible Changes to Your Aquaponics System Over Time** | |
| Rock Cycle | Physical and Chemical Changes |

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| --- |
| **How to Regulate Temperature in Your Aquaponics System** |

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| **Benefits and Limitations of an Aquaponics System** |