Grade: 3-5	**Topic:** Hydroponics	**Lesson (Number/Title):** Comparing Various Hydroponic Systems to Traditional Gardening

Brief Lesson Description:

Students will create hydroponic systems out of upcycled materials in order to compare plants grown without soil to those grown in a more traditional manner. In addition, students will make decisions about a various aspects of their design and test to see which variables are most successful.

Performance Expectations:

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Specific Learning Outcomes:
- Students will identify the resources that plants require from their environment in order to survive.
- Students will explain the role of the leaves, stems, and roots in acquiring these resources from the environment.
- Students will compare qualitative and quantitative data to determine which design is most effective.
- Students will communicate their results with one another in order to identify the aspects of their models that should be carried forward and those that should be eliminated.

Narrative/Background Information:

Background for Teachers:

This lesson is meant to introduce young students to the concept of hydroponic farming. It is the ultimate goal for students to recognize that soil is not necessary for growing a plant. Students should recognize that plants get the materials they need from light, water, and the air around them and only require trace amounts of other nutrients from the soil (or water) they are growing in. Observations should be made with respect to general plant health, height/width, number of leaves, and amount of water needed to keep them growing. Simple charts or narratives can be created to summarize their findings and to help them compare the two growing methods. Students will also be given the opportunity to select independent variables that they would like to see tested in their hydroponic growing system.

Teachers Preparation:
- Plastic bottles (size of your choosing) should be collected ahead of time, rinsed, and have their labels removed. Retain the caps. (Models A and B)
- PVC pipe, fittings, and glue may be needed if you wish to build Model C in the tutorial.

- You should review the attached bill of sale to determine the scope of your participation. If you intend to start from seed, be sure to have all necessary seed starting equipment prior to introducing the lesson.
- You should select a leafy green you would like to experiment with and acquire seeds.
- Seeds should be sewn at least two weeks in advance of implanting them into their systems. If you intend to start the soil control group in their own pots, do so at the same time that you prepare the rockwools.
- Any students that handles the rockwools should wear non-latex gloves, protective eye wear, and should avoid shredding the material so that it is not inhaled.
- Designate a spot in your classroom/greenhouse that will provide ample light for your plants or prepare a growing area that will be equipped with indoor grow lights.
- Hydroponic solutions will need to be prepared with the appropriate pH and nutrient concentrations. Instructions will be included in the tutorial series.

Prior Student Knowledge:

- Students should have a basic understanding of experimental design (aka the scientific method).
- Students should be able to identify basic plant anatomy (roots, stems, leaves, flowers).
- Students should be able to make simple measurements.

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). (4-LS1-1), (5-LS1-1) Construct an argument with evidence, data, and/or a model.(4-LS1-1) Support an argument with evidence, data, or a model.(5-LS1-1) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. (5-ESS3-1) Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5-ESS3-1) **Asking Questions and Defining Problems** Asking questions and defining problems in 3– 5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. (3-5-ETS1-1) Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1) **Constructing Explanations and Designing Solutions**	**LS1.A: Structure and Function** Plants have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1) **LS1.C: Organization for Matter and Energy Flow in Organisms** Plants acquire their material for growth chiefly from air and water. (5-LS1-1) **ESS3.C: Human Impacts on Earth Systems** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1) **ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.(3-5-ETS1-1) **ETS1.B: Developing Possible**	**Systems and System Models** A system can be described in terms of its components and their interactions. (4-LS1-1) **Energy and Matter** Matter is transported into, out of, and within systems. (5-LS1-1), (5-ESS3-1) **Science Addresses Questions About the Natural and Material World.** Science findings are limited to questions that can be answered with empirical evidence.(5-ESS3-1) **Influence of Science, Engineering, and Technology on Society and the Natural World** People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.(3-5-ETS1-2)

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. (3-5-ETS1-2) Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. (3-5-ETS1-3) Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	**Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	

Possible Preconceptions/Misconceptions:

- Plants need dirt in order to grow.
- Plants only need the sun in order to grow.
- Plants require water and fertilizer.
- Plants must grow outside.
- Plants use the oxygen that is in the air.

LESSON PLAN: 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions

A dialogue can be opened in which teachers lead students in a discussion of what types of things settlers would need if they were forced to live in extreme conditions (the desert, the arctic, a space station, or even Mars). It should be highlighted that plants are the beginning of the food chain and will be needed no matter where we go.

You can show them some of the prepackaged, dehydrated food that astronauts eat when they are in space. Ask them why they may prefer to have other options. You can also discuss the other benefits of having plants (air purification, water purification, mental wellness).

Students should also observe different types of dirt and soil (sand, gravel, topsoil) and decide what makes them different and which they think would be best for growing plants and why. Students should also observe different types of hydroponic growing media (perlite, coconut coir, hydroton, rockwool) and ask them what the major differences are.

EXPLORE: Lesson Description -

The lesson will begin with a teacher led narrative to discuss the needs of plants from their environment and how they acquire each resource. Students should then be broken into small groups to discuss what challenges they feel space travelers would encounter while trying to provide these resources to their crops. You may also wish to discuss these same challenges in certain environments here on Earth (deserts, arctic, congested cities, etc).

After thoughts are exchanged in a whole group setting, one should come to the conclusion that plants will needs to be grown indoors and with very scarce resources. It should also be noted that all materials become important in these types of growing conditions and what we may have traditionally considered to be “rubbish” is in fact a useful tool.

Students will be given materials and asked to construct a small planter that is capable of providing water and nutrients to their seedlings (see materials needed below). Three tutorials will be provided with this lesson. The first will discuss building a simple wick system. The second will give instructions on building a simple drip system. The third will give instructions on how to build a more sophisticated wick system for comparison. Options for variables will be provided in the worksheet.

Students will use the provided worksheet to choose their design, evaluate it, and make predictions about what they expect to happen. They should account for how the plants will be acquiring the needed resources from the growing environments you set up.

Over the weeks that follow, students will use the attached data sheets to monitor the differences in their hydroponic planters and their plants growing in soil. Students will be asked to draw conclusions about the pros and cons of hydroponic farming.

Materials Needed:
- Empty 2L plastic bottles (or size of your choosing), caps pre-drilled and cuts started with a hobby knife
- PVC pipe cut to length and fittings(optional if choosing design C)
- ¼ inch braided nylon rope
- Aluminum foil
- Scotch tape
- Pots/containers for plants grown in soil
- Potting soil
- Various hydroponic growing media (perlite, coconut coir, hydroton, rockwool)
- Seedlings (or seeds is starting on your own)
- Hydroponic nutrients (see bill of sale)
- pH adjustment solutions (see bill of sale)

Probing or Clarifying Questions:
1. What makes topsoil different from sand and gravel? Where does this material come from?
2. Why do environments like deserts, the arctic, or space lack these materials in their dirt?
3. What resources would be difficult to come by when growing plants in space?
4. What challenges would astronauts face while trying to grow a crop in space?
5. What benefits besides being a food source would plants provide?

EXPLAIN: Concepts Explained and Vocabulary Defined

Teacher:
- Asks for justifications (evidence) and clarification from students to provide evidence about the decisions they have made in their models.
- Formally provides definitions, explanations, and new labels
- Vocabulary: Photosynthesis, producer, consumer, hydroponics, growing medium, upcycling, variable

Students:
- Uses their recorded observations in explanations.
- Listens critically to others’ explanations.
- Compares data taken from competing designs to form conclusions

ELABORATE: Applications and Extensions

Teacher:
- Refers students to existing data and evidence and asks: What do you already know? Why do you think…?

Students:
- On a blank sheet of paper, encourage students to draw and label their creation once their variables have been chosen.
- Regroup students with new partners and have students check for understanding with their peers.
- Students will communicate with peer groups in different countries to compare the crops they selected and the success in their design.

EVALUATE: Formative Monitoring (Questioning / Discussion):

Teacher:
- Asks open ended questions such as: Why do you think….? How would you explain…? What evidence do you have?
- Introduces the engineering process of iterative design by asking: What mistakes may you have made?....What changes would you make to your next attempt?

Students:
- Answers open ended questions by using observations, evidence, and previously accepted explanations.
- Asks related questions that would encourage future investigations.

Summative Assessment (Quiz / Project / Report): End of Unit group quiz and virtual discussion with international partner classes.

Reflection:

Ask students to observe these concepts in real world applications and explain them using support from their recorded observations.

Common Core State Standards Connections:

ELA/Literacy -
W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)

W.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. *(5-LS1-1)*

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1), (3-5-ETS1-3)

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (5-ESS3-1), (3-5-ETS1-1), (3-5-ETS1-3)

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(5-ESS3-1),* (3-5-ETS1-3)

RI.5.1 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-LS1-1), (5-ESS3-1), (3-5-ETS1-2)

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-ESS3-1)

RI.5.9 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-LS1-1), (5-ESS3-1), (3-5-ETS1-2)

Mathematics -

4.G.A.3 Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. *(4-LS1-1)*

MP.2 Reason abstractly and quantitatively. *(5-LS1-1),* (5-ESS3-1), (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)

MP.4 Model with mathematics. *(5-LS1-1),* (5-ESS3-1), (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)

MP.5 Use appropriate tools strategically. *(5-LS1-1),* (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)

5.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. *(5-LS1-1)*

3-5.OA Operations and Algebraic Thinking *(3-5-ETS1-1),* (3-5-ETS1-2)

Notes for Future Reference: