I. Identification	
Lesson title:	**All this space, and no room to grow**
Teaching unit:	**Space Agriculture in the Classroom**
Lesson number in this unit:	**3 of 7**
Module Correlation:	***Growing Space, Volume 2* (pp. 4-5)**
National Standards:	**Science: A, B, C, D, E, G** **Math: Number & Operations, Algebra, Measurement, Data& Analysis, Reasoning and Proof, Connections** **English: 1, 3, 5, 7, 12**

II. Specific Instructional Objective(s)

Students will be able to:

1. **Identify and explain the Earth and space benefits of two alternative growing techniques (Knowledge and Comprehension domains).**
2. **Differentiate concerns regarding light and photosynthesis between plants grown on Mars and those grown on Earth (Comprehension domain).**
3. **Graph and compare growth rates of selected crops in traditional and alternative growing environments (Application and Evaluation domains).**
1. **Formulate a hypothesis and design an experiment to test growth rates of selected crops in traditional and alternative growing environments (Synthesis domain).**

III. Equipment, materials, supplies, books, resources needed for this lesson (attach handouts):

- **Classroom set of *GS2* (1 per student)**
- **"The Earth as an Apple" digital movie (see "Teacher Resources" below)**
- **"Food Production Challenge" handout (1 per student)**
- **Radish, chives, and lettuce seeds**
- **Growing trays**
- **Potting soil**
- **Liquid soluble fertilizer**
- **Waterproof floral tape**
- **Bib lettuce starter plants**
- **Colored light bulbs (white, blue, red)**
- **Plans for growth chambers**

IV. Teaching Model: Science Inquiry (Joyce, Weil, & Calhoun, 2004; Eggen & Kauchak, 2001)

Set/Interest approach	**Review the challenges that students identified so far that**

(suggested):	**early pioneers encountered as they were settling the west.** **Review concepts of *urbanization* and *habitation.* Remind students that one area to investigate on their journey through space with agriculture is the concern about avoiding urbanization problems through planned habitation.** **Show students movie entitled, "The Earth as an Apple." Following the movie, ask students to identify the "problem" presented in the movie.** **(Students should present concerns with so little land producing so much food, cities overtaking agricultural production areas, potential conflicts between agriculturists and consumers, and others)**
Stated objective(s) (suggested):	**Today, we will focus only on concerns about growing food – both on Mars and on Earth, with the idea of investigating alternative ways to produce food. In addition, you will be asked to design and carry out an experiment that compares traditional and alternative growing techniques, and decide which is better for growing food on Earth and in space.**
Purpose (suggested):	**As we watched in the movie, we need to be concerned about how to produce food for a growing population for a long time to come, so through this lesson, we will be able to see that there are alternative ways of producing agricultural products.**
Presentation: **Objective 1** • **Teacher asks students to identify problems and potential solutions to growing food on Earth.** • **After compiling list, teacher asks students to read *Growing Space, Volume 2* (pp. 4-5). Stop before reading "How Does a Mars Garden Grow?"**	**Teaching methods** • **Individual brainstorming ("Food Production Challenge" handouts).** • **Small group consolidation of lists.** • **Whole group report out; teacher captures responses on board.** • **Reading method is teacher's choice.** • **Teacher should discuss hydroponics and intercropping with students to tease out more questions they have, and to clear up any concerns/misconceptions about either technique (see "Teacher Resources" section for links to**

• **Ask students to compare their proposed solutions to the alternative growing techniques in the reading.**	**hydroponics and intercropping teacher background information).**
Check for understanding: Objective 1	• **Ask students to draw an illustration of the two alternative growing techniques.** • **Students should then develop a list of potential benefits of each technique as it relates to use on Earth and on Mars.**
Objective 2 • **Teacher asks students to read "How Does a Mars Garden Grow?" (p. 5)** • **Students should identify potential difficulties regarding light and growing plants on Mars.**	• **Reading method is teacher's choice.** • **Teacher leads inquiry discussion with students about light and effects of light on photosynthesis.** - **Green plants absorb sunlight** - **Use to produce sugar** - **Take water into system** - **Release energy**
Objective 3 • **Students and teacher will investigate how salad crops grow in traditional, hydroponics, and intercropping growing situations, and in different levels, lengths, and types of light.** • **Teacher helps students to:** - **State a hypothesis** - **Design and set up an experiment**	• **Individually, in small groups, or as a class.** • **Use growing trays, potting mix, water, and liquid soluble fertilizer with lettuce, radish, and chives seeds, and lettuce starter plants.** • **Students can set up** - **traditional growing set-up (1 crop/tray in potting soil)** - **hydroponics set-up (1 crop/tray in fertilizer solution)** - **hydroponics & intercropping (3 crops/tray**

<table>
<tr><td>incorporating a variety of the options available.</td><td>in fertilizer solution)
- intercropping (3 crops/tray in potting soil)
• Follow seed and starter plant recommendations.</td></tr>
<tr><td>Check for understanding: Objective 3</td><td>• Students should formulate hypotheses and create a written plan for their experimental design (materials, procedures, expected outcomes, potential costs, etc.), reviewed by the teacher, before proceeding with the construction of their experiment.</td></tr>
<tr><td>Objective 4
• Students will clear up any difficulties with the problem by generating data from the experiment.</td><td>• Students will collect data over a two-week period measuring growth, recording plant appearance, and other appropriate data collection.
<table><tr><th>Plant #</th><th>Date</th><th>Plant growth (cm)</th><th>Leaf Color</th><th># of New Leaves</th><th>Comments</th></tr><tr><td>1</td><td>M/d</td><td>5</td><td>Dark green</td><td>1</td><td>New leaf still very immature</td></tr></table></td></tr>
<tr><td>Check for understanding: Objective 4</td><td>• Students will draw conclusions and make inferences about which plants grow best in which environments.
• Possible conclusions will relate to which grew best, in which circumstances, rationale for their conclusions, recommendations for future experimentation.</td></tr>
<tr><td>Closure (suggested):</td><td>Play “The Earth as an Apple” digital movie again. Allow students to generate a class poster or list or illustration of what their Mars greenhouse should look like, based on their experiment results.</td></tr>
<tr><td>Independent practice (suggested):</td><td>• Students will compile data on their own to create a laboratory report with conclusions to retain or reject hypotheses (see laboratory report rubric example).</td></tr>
</table>

V. Extension/Quest activities (optional, if time permits):
Students can take photographs throughout the design, construction, and observation periods and create science fair projects based on growing media and light exposure.

VII. Teacher Resources
The Earth as an Apple movie: http://www.farmland.org/what/apple_movie.htm
Agriscience Fair information: http://www.sciencebuddies.org/mentoring/project_display_board.shtml
Mars information: http://physics.ucsd.edu/~cdpgrad/mars.html
USDA sustainable agriculture information: http://www.nal.usda.gov/afsic/AFSIC_pubs/srb9902.htm
Hydroponics information: http://www.ext.vt.edu/pubs/envirohort/426-084/426-084.html http://www.hydroponicsonline.com/lessons/Introduction/Lesson1-3.htm
Iowa State University Intercropping information: http://www.pfi.iastate.edu/ofr/RT_strip_intercropping.htm
Photosynthetic process information: http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookPS.html

Name: _____
Date: _____

Food Production Challenge

The problem: As you viewed the digital movie, you identified many challenges for agriculture on Earth. One of those problems was how to produce food efficiently.

The assignment: First, on your own, brainstorm as many problems and potential solutions for producing food on Earth as you can.

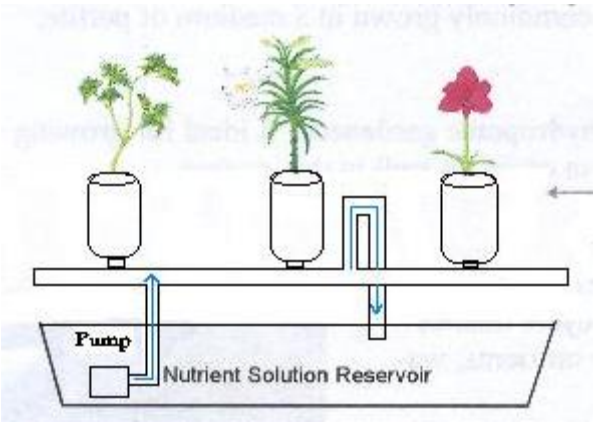
Then, within your small group, compile your solutions. Consolidate similar answers, so that there are no duplications.

Finally, as a group, place a number one (1) next to the problem and the solution that you think is the most realistic and transferable as we adapt crop production practices for use on Mars.

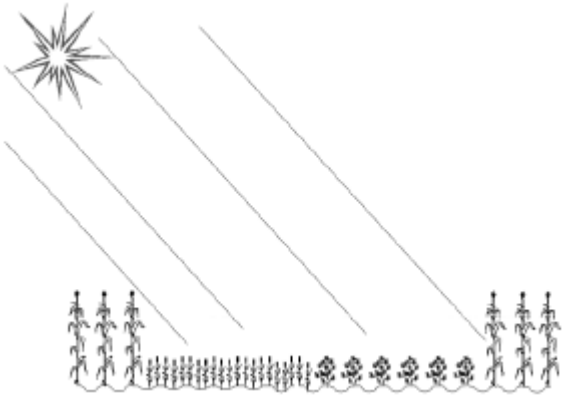
Problem	Proposed Solution
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Hydroponics and Intercropping

Student illustrations may resemble these:



Hydroponics (Courtesy of http://www.hydroponicsonline.com/lessons/Introduction/Lesson1-3.htm)



Intercropping (Courtesy http://www.pfi.iastate.edu/ofr/RT_strip_intercropping.htm)

Laboratory Report Grading Rubric

(http://www.gar-field.org/departments/science/willis/preibphysics/labrubric.htm)

At the conclusion of each laboratory activity you will be expected to write up a report..I have provided below a list of the major topics, which must be included in your report and the points assigned to each category

I. **Title:(2 points)** (A short paragraph which describes what the lab is about)

- Title is not a question
- Title is relevant to the experiment

II. **Planning (a)**

Research Question: (5 points) (What is it we want to find out)…Can I...?

- Purpose is clearly stated and should be in the form of a question.

Hypothesis: (6 points) (A guess of the answer or outcome on your part…what do you expect to show?)

- The hypothesis statement is directly related to the purpose of the investigation.
- The hypothesis is not in the form of a question.
- Be sure to state why you believe your hypothesis to be true.

Variables: (4 points) (Identify all reasonable variables that might affect the outcome of the activity)

- Identify the independent variables
- Identify the dependent variables
- Identify those variables that will be controlled.
- Be sure to explain why each variable listed above is relevant!!

III. **Planning (b)**

Research:(2 points) (What is already known about this problem?)

- Summarize in a paragraph what have you been able to learn about the problem you are about to investigate from the Internet, a literature search in the library, or even from reading your textbook, etc.

Materials: **(8 points)** (A list of all materials you will require to conduct the lab activity)

- ALL materials/equipment needed to perform the investigation are listed.
- Be specific when you list items...don't just say measuring equipment, say what type of measuring equipment such as a “thermometer that measure between 0 and 100 degrees Centigrade graduated in one degree measurements” or “several different masses between 50 and 200 grams”.
- Safety equipment is listed.
- Indicate what controls you will impose on your variables and how you will maintain those controls.

Procedure: (16 points) (The "experiment" part of the scientific method…a step by step set of instructions of what is to be done in the experiment phase of the investigation. **All safety issues and concerns must be addressed in this portion of the report**.)

- Safety concerns are among the first steps listed.
- The procedures required to collect sufficient and relevant raw data are clear, concise and complete sentences.

- The procedural steps are **sufficient in number** so someone totally unfamiliar with the investigation can perform the experiment.
- You may want to include a digital picture of all equipment set-ups required during the course of data collection. I have a camera for this!!

IV. **Data Collection**

Results and Observations: (18 points) (The "data analysis" part of the scientific method…Report all recorded observations and data in this part of your report.

- **All** data (qualitative and quantitative) collected that you recorded in your lab notebook should be repeated here as well. Source of data is indicated and the how it was collected is should be mentioned. You will probably have to repeat some of the words used in the procedure section.
- Raw data should be presented clearly, allowing for easy interpretation.
- Raw data tables reflect uncertainties and errors.

V. **Data Analysis (18 points)**

- Raw data is processed correctly. Error analysis is included as needed.
- Appropriate tables and graphs are present and where possible are created on graphing calculators and imported into your report.
- All graphs are **labeled and fully explained**.
- Graphs and tables contained in the report are relevant to the data collected.
- Possible errors (in particular, **measurement**) that may have occurred are identified and what steps were taken to reduce their influence is discussed.
- Graphs reflect the appropriate "error bars" as needed.
- Data presented in tables are reported to the appropriate number of significant digits.

VI. **Conclusion/Evaluation (16 points)**

In this portion of the report you indicate your judgments made / decisions reached based on your observations and data collected. Most important, you indicate whether or not you elect to support or to reject your hypothesis made above (section III) in this section of your report.

- A valid conclusion focuses on your decision to continue to support your hypothesis and why you elected to do so... OR
- A valid conclusion focuses on your decision to reject your hypothesis and why you elected to do so
- **In either case you need to make reference to your results and observations section above as to why you reached the decision you did.** You must substantiate your decision to accept or reject...not just a statement you do or you do not accept your hypothesis. Tell me why you made the decision you did.
- Comment on the limitations and weaknesses of the materials and procedures used.
- Make suggestions as to how to improve the investigation.
- Include your answers to the "reflection questions" I may ask you to address after we have completed the lab. Be sure to include the questions in your report as well as your answers to the questions.

VII. **Manipulative Skills and Personal Skills(5 points)**

I will observe you during your data collection. I will make note of the various techniques you used in your lab activity. I will make note of how involved you are with your group, how much you contribute to the lab, how well you followed established instructions in particular those related to safety and how much of a "team player" you proved to be.