I. Identification	
Lesson title:	**Smart Plants**
Teaching unit:	**Space Agriculture in the Classroom**
Lesson number in this unit:	**4 of 7**
Module Correlation:	***Growing Space, Volume 2* (pp. 6-7)**
National Standards:	**Science: A, B, C, D, E** **Math: Algebra Standard, Data Analysis, Connection** **Language Arts: 1, 3, 8, 12**

II. Specific Instructional Objective(s)

Students will be able to:

1. **Define biotechnology**
2. **Compare and contrast a mini-greenhouse with a Mars greenhouse**
3. **Evaluate Martian soil**

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

- **Flip chart or poster board pages for K-W-L chart**
- **Inflatable beach ball**
- **2 liter plastic bottle**
- **Planting soil**
- **Seeds (preferably fast germinating seeds like lettuce, radish, onion)**
- **Water**
- **Scissors or box cutter**
- **Sandpaper**
- **3 glass containers per group or per three groups (teacher choice)**
- **Salt**
- **Yeast**
- **Baking powder**
- **Clean sand**
- **Sugar**
- **Permanent marker**

IV. Teaching Model:	
Set/Interest approach (suggested):	**Using a Know-Want to Know-Learned (K-W-L) chart, ask students to articulate what they <u>know</u> about how plants grow, as well as what they need to grow, on Earth.** **Use the "Want to Know" chart to capture**

	what students want to learn about how plants may eventually grow on Mars. **(Optional: Teacher may want to have each student construct their own K-W-L chart before constructing a classroom version. Use the attached instructions for the three-part paper book for student K-W-L charts.)**
Stated objective(s) (suggested):	**By the end of this lesson, we will be able to define biotechnology and what it means as we look toward lunar and planetary travel. We will also be able to compare and contrast a mini-greenhouse with potential Martian greenhouses, as well as evaluate Martian soil through experimentation.**
Purpose (suggested):	**It's important to consider how plants can grow when Mars lacks what we know plants need to grow here on Earth (air, water, nutrient-rich soil), as well as how we will be able to meet plant needs from Earth before we travel to the planetary surface.**
Presentation: **Objective 1** • **Engage students in reading pp 6-7 of the reading module ("Smart Plants")** • **Read out loud the definition of "biotechnology" from the glossary.** • **After the teacher has read the biotechnology "Myths & Facts" information and the programmable cells background information (see links listed below), teacher engages students in a reflective observation over the**	**Teaching methods** • **Method is teacher's choice – aloud (only if student ability supports this method), silently, in reading support groups, and others.** • **As students read, encourage them to use the glossary in the back of the module (pp. 14-15).** • **Teacher should write vocabulary words on the board and say them for the students.** • **Divide students into groups of four.** • **Students should conduct a group investigation regarding items in their world that use biotechnology. Student groups can write or draw their lists on a poster board or other recording means.** • **Reflection may include one or more of the following: group discussion, journaling, pair share, etc.**

information they have read and investigated regarding biotechnology. • **Teacher should assist students through the abstract conceptualization portion of experiential learning by presenting information learned from the background information that students may need, as teacher deems appropriate.**	• **Present information specific to implanting plants with programmable technology. Engage student learning through questioning regarding how this may be applicable in Earth today.**
Check for understanding: Objective 1	• **Beach ball review over pp. 6-7 "Smart Plants" section** • **Use a permanent marker to number the segments of the beach ball (or write questions directly on the ball).** • **When students catch the ball, explain that one hand (right or left) covering the number will determine which question is answered.** • **Review questions may include:** • **What types of products will we use plants for? (food, clothing, water, oxygen, medicines, shelter, fiber, flavoring, perfumes, soaps)** • **What is the purpose of programming plants?** • **What is *hypogravity?*** • **How would sending programmable plants to the moon and Mars benefit future space travel? (use technology to adjust plant growth to create a suitable place to live)** • **What are some applications for programmable plant technology?** • **What are questions that scientists can study related to plant growth in space?** • **Others? (Teacher added questions here)** • •

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Objective 2 • **Construction of miniature greenhouses (this can be done earlier in the unit and referred to now for growing, or it can be constructed as part of this lesson and the teacher can help students draw inferences between this and the Mars miniature greenhouses in the reading module.)** • **Students can construct individual greenhouses, work in pairs, or create a class greenhouse. *Individual or pair construction is optimal.***	• **Miniature greenhouse instructions** • **Using the 2 liter bottle, cut down from the top of the bottle 4 inches all the way around.** • **Rub edges of bottle with sandpaper to smooth them.** • **Fill bottom of bottle 4-6 inches with dirt.** • **Plant seeds and water gently (for fastest results, plant seeds somewhat near the surface).** • **Place top back on to encourage dew to collect for self-watering.** • **Place in a sunny window and watch for growth changes.** • **Extension: students can measure plant growth and experiment with different levels of light.**
Check for understanding: Objective 2	• **Students should compare and contrast a Mars greenhouse with the miniature greenhouse (air pressure, light availability, etc.)** • **Teachers can refer to the background information accessible from the websites listed below.**
Objective 3 • **Evaluate "Martian" soil** • **Allow students to brainstorm answers to the question.**	• **"One of the most important products necessary for plant growth and viability is soil. There are nutrients to help plants grow, it provides an anchor for root and stem growth, and it holds water that plants can access for stem and leaf turgidity and to complete the photosynthetic process.** • **"Why can't we just use the soil on the surface of Mars like we use it here on Earth?" (lacks nutrients, lacks readily available water source, climate temperatures are too extreme)**

• **Testing "Martian" soil experiment** • **TEACHER'S NOTE: If living cells are present, such as in yeast, a reaction will occur slowly and continually as they multiply. Other chemicals may cause a reaction for a short period of time only.** • **Source: Zike, D., & Simpson, S. (2001) *The World of Space*. Melrose, FL: Common Sense Press.** • **TEACHER'S NOTE: Due to variation in class schedules, be sure to conduct this experiment before presenting to students. The one- and three-hour observation periods may require adjustments in presentation approach.**	• **"What can we do to demonstrate the lack of viable organisms in soil?"** • **We can test our own "Martian" soil!** • **Divide students into groups (there are three variables, so teacher should decide if each group will conduct all three investigations, or if three groups will each conduct one investigation. This will have a bearing on the number of glass containers required).** • **See attached instructions for printable version of Martian soil test experiment.** • **When the experiment is complete, ask students to describe the solution in each container. Which container contains life? What evidence can students find to support their supposition?**
Closure (suggested):	**Students will complete their K-W-L chart(s) by filling in the "what I learned" section. This should be completed as a group or individually, in the same manner as the beginning of the lesson.**
Independent practice (suggested):	• **Based on what students have learned about the Martian surface and how plants will have to grow in greenhouses, have students design a garden plan for a Mars greenhouse. They should draw it, color it, describe it, and be able to defend why it is appropriate for growth on Mars, as well as how they will ensure that plant needs are being met for maximum production.**

V. Extension/Quest activities (optional, if time permits):
Students can build a more extensive model (diorama or other three-dimensional product) of a Mars greenhouse project.

VI. Assessment

Teacher determined.

VII. Teacher Resources

Biotechnology "Myths & Facts" information:
http://www.bio.org/foodag/facts.asp

Programmable cells background information:
http://www.sciencedaily.com/releases/2005/04/050427201634.htm

"Leafy Green Astronauts" teacher background information:
http://science.nasa.gov/headlines/y2001/ast09apr%5F1.htm

Miniature greenhouse instructions:
http://www.theideabox.com/Mini_Greenhouse.html

Zike, D., & Simpson, S. (2001) *The World of Space*. Melrose, FL: Common Sense Press.

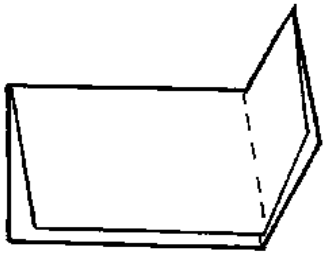
"Know?-Like to Know?-Learned?" Three-Tab Book instructions

Zike, D. (2001). *Big book of science for middle school and high school.* San Antonio, TX: Dinah-Might Adventures, LP.

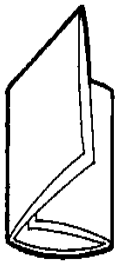
1. Fold a sheet of paper in half vertically (like a hot dog).

2. With the paper horizontal, and the fold at the top, fold the right side toward the center, trying to cover one half of the paper.

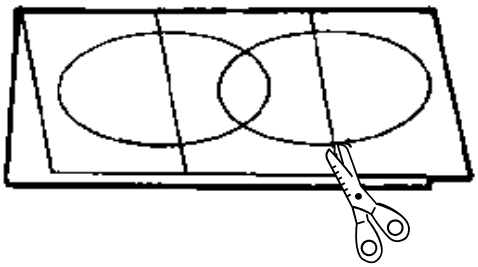
NOTE: *If you fold the right edge over the first, the final graphic organizer will open and close like a book.*



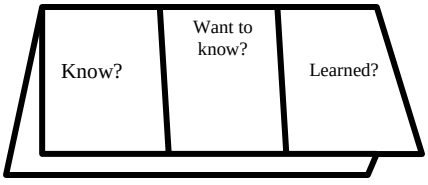
3. Fold the left side over the right side to make a book with three folds.



4. Open the folded book. Place your hands between the two thicknesses of paper and cut up the two valleys on one side only. This will form three tabs.



5. On the left tab, have students write, "What do I know?" On the center tab, have students write, "What do I want to know?" On the right tab, have students write, "What did I learn?" They can then lift the corresponding tab and write their thoughts/observations/information in the correct area.



Alternate Form "Know?-Want to Know?-Learned?" Chart

Name: _____

Plant growth on Earth & Mars		
What do I know?	**What do I want to know?**	**What did I learn?**

Testing Martian Soil

Name: _____
Date: _____
Group Number: _____

Materials:

Glass containers
Salt
Yeast
Baking powder
Clean sand
Sugar
Permanent marker
Refrigeration
Warm water source
Measuring tools: tablespoon, ½ cup

Instructions:

1) With the permanent marker, label containers A, B, and C.

2) Fill each container one-third full with clean sand.

3) Add three tablespoons of salt to container A and mix.

4) Add three tablespoons of baking powder to container B and mix.

5) Add three tablespoons, or packages, of yeast to container C and mix.

6) Place the containers in the refrigerator overnight, simulating the cold temperatures on Mars.

7) **On day two,** mix two cups warm water and ½ cup sugar.

8) Remove containers from the refrigerator.

9) Pour equal amounts of the sugar solution into each container.

10) After one hour, observe the containers and record observations.

11) After three hours, observe the containers and record observations.

Observations:

Container	1 hour	3 hours
A		
B		
C		

Questions:

1) Describe the solution in each container:

2) Which container do you think contains life?

3) What evidence did you see that supports your answer from question 2?