Lunar Plant Growth Chamber

LESSON THEME
An activity to grow plants in an environment similar to the moon designed in a unique partnership between NASA scientists and engineers and education professionals. The lesson incorporates leading-edge insight and practical experiences for students on how NASA works on plants.

NASA SUMMER OF INNOVATION

UNIT
Engineering

GRADE LEVELS
5-8

CONNECTION TO CURRICULUM
Life Science, Technology

TEACHER PREPARATION TIME
3hours

LESSON TIME NEEDED
12-18 days *Complexity: Advanced*

OBJECTIVES
Students will:
- Describe the need for life science research on the International Space Station and the moon.
- Identify various plant species that are suitable for lunar plant growth and their requirements.

NATIONAL STANDARDS
National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- An appreciation of "How we know" what we know in science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities and attitudes associated with science.

Life Sciences
- *Organisms and environments*

Science in Technology
- Abilities of technological design

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
- Apply existing knowledge to generate new ideas, products, or processes

Critical Thinking, Problem Solving, and Decision Making
- Plan and manage activities to develop a solution or complete a project

Research and Information Fluency
- Plan strategies to guide inquiry
- Locate, organize, analyze, evaluate, synthesize, and ethically use
- information from a variety of sources and media
- Evaluate and select information sources and digital tools based on the
- appropriateness to specific tasks
- Process data and report results

Technology Operations and Concepts
- Understand and use technology systems
- Select and use applications effectively and productively
- Troubleshoot systems and applications

MANAGEMENT

Students should have access to information-gathering and research equipment.
Students should have room for small group and whole class discussions.

CONTENT RESEARCH

Teacher preparation for this unit includes the following:
• Review the first three lessons and the additional "build" lesson at the end of the Challenge. Review the Vision for Space Exploration and the Ares launch vehicles (***Ares*** video).
• Gather references and compile a list of suggested Internet sites to visit. As students discover good references, Internet sites, films/documentaries, etc., the teacher should add these to the list to develop a data base.
• Research other experiments where plants were grown on the space shuttle, Mir and the International Space Station (ISS).

MATERIALS

Research materials
• Computers with Internet access
• Printers
• Presentation equipment
• See also the ***Design Challenge Brief*** in Appendix
- Worksheet: ***Growth Chamber Plant List*** in Appendix
- Worksheet: ***Top Five Plant List Worksheet***

• Rulers
• Art knives and/or scissors
• Poster board, tag board and/or Cardboard
• Hot glue and glue guns
Masking tape and/or packing tape
(A number of readily available materials may be used for building the lunar plant growth chamber.)
• Plywood
• Wood glue and/or plastic cement
• Staple gun and staples
• Electric wire
• Clear plastic sheet
• Acrylic
• Screws and nails
• Plastic tubing and syringes
• Light bulbs and fixtures, hinges

KEY Concepts:

- **Greenhouse** - a glass or transparent plastic structure, often on a metal or wooden frame, in which plants that need heat, light, and protection from the weather are grown
- **Growth Chamber**-Two classes of environmental control units are available for researchers who need controlled temperature and humidity for small experiments, whether they are botanical or entomological. Currently, there is one *Arabidopsis*-style ´double-decker´ chamber with better temperature and humidity control than the six older chambers. There are also two new upright (refrigerator-style) chambers and one older incubation chamber. Users must justify access to the newer chambers in their applications, if they are requested. Please see the application for more detailed information on controlled environmental chambers.
- The **International Space Station** (**ISS**) is an internationally developed research facility with 16 international member countries. First begun in 1998, the ISS has been completed in 2011. Humans have lived onboard since 2000.
- **MIR**- was a Soviet and later Russian space station, operational in low Earth orbit from 1986 to 2001. With a greater mass than that of any previous space station, *Mir* was the first of the third generation of space stations.
- **Species**-A group of organisms having common attributes and given a common name.
- **STS-118** - was a space shuttle mission to the International Space Station (ISS) flown by the orbiter Endeavour. STS-118 successfully lifted off in 2007 with student plant experiments involving basil seeds onboard.

LESSON ACTIVITIES

Lesson 1: Introduction to STS-118 Mission and the Design Challenge
http://er.jsc.nasa.gov/seh/main_EDC_Lunar_Plant_Growth_Chamber.pdf

Lesson 2: Choosing Plant Species Students inspect the list of plants with their positive and negative characteristics from Lesson 1 and select five plants they would like to study further. With a partner, students research the plants they have selected to determine the plants requirements for healthy growth.

Lesson 3: Designing the Plant Growth Chamber
Students list all the subsystems they need to design in order to meet the requirements of their selected plant species. Students search the Internet for descriptions, sketches, drawings, etc. of proposed lunar habitats, greenhouses and other structures.

Lesson 4: Building the Plant Growth Chamber
Students build and use growth chambers of their own design.

ADDITIONAL RESOURCES

- OUR World- Plants in Space video eClip:
  http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=&category=1000 .
  Join the Challenge:
  http://www.nasa.gov/audience/foreducators/plantgrowth/joinchallenge/index.html
- The STS-118 Education Resources can found by searching www.nasa.gov/sts118.
- *International space station research summary through expedition 10.* (2006).
  http://ston.jsc.nasa.gov/collections/TRS
  http://www.space.com/businesstechnology/technology/light_farming_010926.html
- *Teaming up on space plants*. http://science.nasa.gov/headlines/y2001/ast10may_1.html
- *Solar growth chambers for NASA*. http://ag.arizona.edu/pubs/general/resrpt1998/nasa.html
- *Education payload operations: Kit C plant growth chambers (EPO-Kit-C). Astroculture plant growth chamber* (*ASC-GC*).http://wcsar.engr.wisc.edu/asc-gc.html
- *The aerospace catalyst experiences for students (ACES) project*.
  http://laspace.lsu.edu/aces/Presentations.html

DISCUSSION QUESTIONS

- Most scientists do not believe that lunar colonists could grow all the food they would need. Why should they grow any food? *Answers may include, but are not limited to the need for supplements to the pre-packaged meals, psychological effects of growing plants, and experimentation for future exploration beyond the moon.*

- A growth chamber on the moon would need to be large enough for the plants that will be grown there. What mathematical formula would be used to calculate volume? *Answers will vary, but should give a valid formula for volume such as surface area multiplied by height)*

- Describe two characteristics plants should have in order to be considered suitable for a lunar greenhouse. *Answers could include any two of the following: High Growth Rates, Small Waste Percentage, Low Maintenance, High Yield of Oxygen, and Small Growing Area. Other options may be acceptable depending upon class discussions.*

- Describe how one of these models could be used to evaluate a design solution. *Evaluating a design solution can be done using conceptual, physical and mathematical models.*

- Describe conditions on the moon that necessitate a closed, artificial environment in which to grow plants. *Should include: Lack of atmosphere, Lack of nutrients in regolith, lack of available ambient moisture and duration of daylight.)*

- List and explain two important topics that must be addressed in the Preliminary Design Process.
  During the design process, a number of prototypes of a design solution may be built. Conceptual – gives overview of requirements and requires address of design constraints, needs, and efficiency Physical – Allows for testing of systems to evaluate design
  Mathematical – allows for computer simulation of design

- Describe two characteristic differences in the models from one generation to the next. *Answers will vary.*

- Describe two components of a Critical Design Review that differentiates it from the Preliminary Design Review. *Answers will vary.*

ASSESSMENT ACTIVITIES

A ***Unit Pre- and Post-Test*** is provided that includes questions from each lesson. It represents the knowledge assessment component for each lesson, but it may be used as a pre-assessment tool.

• Assessment for each lesson includes a quiz, and rubrics will be used for group work and/or the research, analysis and presentation.

ENRICHMENT

- Students may wish to germinate seeds from their selected species and grow them in class in order to record baselines for comparison, should they decide to grow these species in their chambers. This is done under regular Earth conditions (i.e. sunlight, potting soil, daily watering). *Teacher's Note*: Registering to implement the STS-118 Design Challenge includes the opportunity to obtain space-flown cinnamon basil seeds to grow in the completed plant growth chamber. Seeds are available through NASA CORE, at core.nasa.gov
- Students may wish to repeat the above experiment, changing only one variable to replicate a condition that will be present in their LPGC (i.e., different wave lengths of light, limited light, nutrient rich water/hydroponic system, high/low pH of the growth medium, etc.).