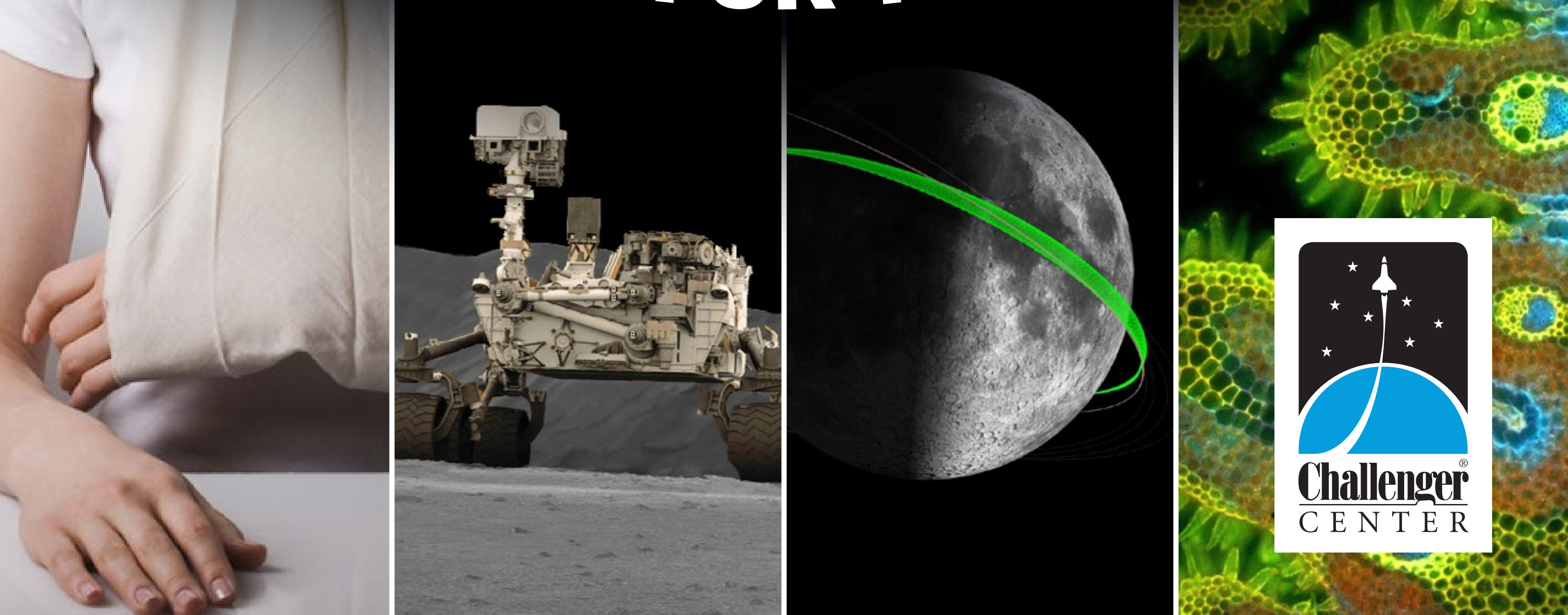
LUNAR QUEST™

TEACHER'S RESOURCE

PREPARING FOR THE MISSION



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OUR HISTORY

On January 28, 1986, the seven crew members of the Space Shuttle Challenger/STS-51L "Teacher in Space" mission set out to broaden educational horizons and advance scientific knowledge. Their mission exemplified man's noblest and most wondrous qualities – to explore, discover, and teach. To the nation's shock and sorrow, their Space Shuttle exploded 73 seconds after liftoff.

In the aftermath of the Challenger accident, the crew's families came together, firmly committed to the belief that they must carry on the spirit of their loved ones by continuing the Challenger crew's educational mission. In April 1986, they created Challenger Center for Space Science Education (Challenger Center).

They envisioned a place where children, teachers and citizens alike could touch the future, manipulate equipment, conduct experiments, solve problems, and work together-immersing themselves in space-like surroundings. The goal: to spark youth interest and joy in science, technology, engineering and math; a spark that could change their lives and better our world. The result – the creation of the Challenger Learning Center.

A trip to one of more than 40 Challenger Learning Centers brings classroom lessons to life. It's a trip into space. The simulated environment is created with computer technology, real science data, hands-on activities and standards-aligned content. Complete with Mission Control and the orbiting Space Station, students becomes astronauts, scientists, engineers, researchers and more as they all share the thrill of discovery.

Our students of the universe will change the world. Thank you for joining us on this mission!

To learn more about Challenger Center, visit www.challenger.org

WHAT TO EXPECT THE DAY OF YOUR MISSION

Students should have their mission assignments finalized when they arrive at the Challenger Learning Center. There are nine teams used during Lunar Quest. Each team includes two members – one will work in Mission Control and the other on the Space Station. Lunar Quest mission teams include:

- **Rover (ROV)**
- **Robotics (BOT)**
- **Life Support (LS)**
- **Geology (GEO)**
- **Communications (COM)**
- **Astrobiology (BIO)**
- **Medical (MED)**
- **Space Weather (SW)**
- **Navigation (NAV)**
- **HAZARD (HAZ)**

When students arrive at the Challenger Learning Center, a short briefing is held in which the students learn about the Challenger STS 51-L crew, receive an overview of their mission, and learn about their assignments. Students then split into the two groups with one member of each team represented in Mission Control while their team counterparts are transported to the Space Station.

Once situated, Lunar Quest begins. Students follow instructions at their work stations to conduct research, collect data, send messages, and work as a team. At the mission's halfway point, the partners exchange places with the group in Mission Control being transported to the Space Station and the group in the Space Station moving to Mission Control. This exchange allows for every student to experience both of the Center's learning environments.

About Lunar Quest

During Lunar Quest, students take on the role of scientists, engineers and doctors to explore the moon and locate precious materials. Students will work as both Mission Controllers and Astronauts focusing on four major topics:

- Orbtial mechanics and what it takes to get to the moon
- Health and safety in space
- Conditions for life
- How remote sensing enables us to observe and explore the moon in ways that would otherwise be impossible

COMMON CORE & NEXT GENERATION SCIENCE STANDARDS (NGSS)

Challenger Center's educational pedagogy promotes scientific literacy by encouraging exploration and inquiry and exciting young people about knowledge and learning. Using our interdisciplinary, inquiry-based approach that incorporates national educational standards, Challenger Center strives to:

- Increase student interest in science, technology, engineering and math.
- Give abstract concepts concrete meaning.
- Help students develop realistic processes of team work, communication, critical thinking, and problem solving.
- Increase student autonomy and responsibility for their learning.
- Encourage students to develop positive perspectives about learning.
- Increase student commitment to learning.

Challenger Center programs are designed to reflect academic standards and support the work being completed in the classroom. The mission should not be seen as a one-off activity, but rather it should be viewed as another way to engage students and support the current curriculum.

Standards Alignment

	Health in Space: Problem Solving through Engineering	Rover Races: The Search for Minerals	Orbital Mechanics: Landing on the Moon	The Search for Life
NGSS	**MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.	**MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.	**MS-PS2-5** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. **MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.	**MS-PS2-5** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
Common Core	**MP.2** Reason abstractly and quantitatively.	**MP.2** Reason abstractly and quantitatively.	**MP.2** Reason abstractly and quantitatively.	**WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated) question, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **MP.2** Reason abstractly and quantitatively.

HEALTH IN SPACE:
PROBLEM SOLVING THROUGH ENGINEERING

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PROBLEM SOLVING THROUGH ENGINEERING

INTRODUCTION

In this lesson, students are divided into small groups and tasked with finding a solution to fix a broken bone in a space (microgravity) environment. This requires a general understanding of bones and their structure, as well as significant problem solving skills utilizing the basic materials available to repair the situation.

LESSON OVERVIEW

Subject & Grade Level: Science, 5 – 8 Grade

Length: 45 minutes (1 full class session)

Objectives

At the conclusion of this lesson students will be able to:

- Describe basic bone structure and functionality in space and on Earth.
- Determine class-wide best practices of how to fix a broken bone in both a space and Earth environments.
- Demonstrate a basic knowledge of orthopedics, and compare and contrast bone care as it relates to a space or Earth environment.

Key Questions

- What is the basic anatomy of bones in the arm?
- What are the key differences between bone growth in space and on Earth?
- How do you problem solve when you do not have all necessary materials?
- Can materials be used in ways that differ from their primary function to help solve problems that have occurred due to an emergency or accident?

Standards

- NGSS MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- NGSS MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Common Core MP.2: Reason abstractly and quantitatively.

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Materials Needed

Depending on the class size and how many different groups of student you form (*we recommend groups of about 4 to 5*), each group will need the following to complete this lesson (*it may be easier to provide students with a box/basket that contains all of the needed and prepared materials*).

- HIS Reproducible 1
- HIS Reproducible 2
- 1 meter stick (ruler or dowel rod)
- 1 roll of duct tape
- 10-15 unsharpened wooden pencils
- 2 pieces of 8” x 11” construction paper
- 2-3 bandanas or a small throw blanket or a pillow case
- 2-3 balloons
- 1-2 plastic soda bottles
- 1 roll of masking tape

Background Information: Teacher Knowledge

As we continue to branch out of our own orbit through space exploration, different situations will undoubtedly present themselves. Astronauts go through intense preparation, complete with a number of health and physical fitness checks. However, we can never truly be prepared for the types of emergencies that may present themselves during space travel or how astronauts will problem solve and use what they have at their disposal to ensure the safe return of all those involved.

In this lesson, students focus on a “what if” scenario. During this scenario, a fellow astronaut (one in their group) has broken a bone in space (specific bone location is up to the teacher, but we recommend the arm). The students must problem solve to create a method to stabilize the bone until they can return to their home base.

What makes this situation interesting and slightly more difficult is that most astronauts suffer from loss of bone mass in space. Therefore there is a larger risk of broken bones as time passes in space. Although there has never been a broken bone in the microgravity environment, problem solving is an efficient way to find the best solution to deal with the situation if it were to arise.

Resources

Bone Mass in Space
http://science.nasa.gov/science-news/science-at-nasa/2001/ast01oct_1/

http://www.nbcnews.com/id/3077393/ns/technology_and_science-science/t/why-do-bones-weaken-space/#.U6LWTPldWSo

Medical History on the ISS
http://www.nasa.gov/mission_pages/station/research/experiments/1025.html

How to provide first aid for a broken bone
http://www.wikihow.com/Provide-First-Aid-for-a-Broken-Bone

Additional Resources

Muscle Atrophy in Space
http://www.nasa.gov/mission_pages/station/research/experiments/245.html

LESSON STEPS

Teacher Preparation

To prepare for this lesson, teachers must have reviewed the basic bone mass materials and understand how bones themselves are repaired in the short term using splints. They must also have a basic working knowledge of space and microgravity situations. Teachers also must gather the necessary materials for everything to work well.

Note: It may be easier to provide students with a box/basket that contains all of the needed and prepared materials.

Warm-up

Ask the students what they know about basic human anatomy to gather their understanding. This could include things such as:

What is a bone? What do bones do?

They support and protect the various organs of the body.

They produce red and white blood cells and store minerals.

The structure of bones provides shape to your body. This can determine your height or body type.

Bones work hand-in-hand with muscles and ligaments to create movement.

Show students two images (HIS Reproducible 1) individually and then have the students compare and analyze both images. Ask the students to write down what they think they see and list any possible similarities or differences (one is an image of a normal bone, the other is a bone that suffers from osteoporosis).

Engage the students in a classroom discussion about the differences between the two images and what they wrote down. Have this discussion lead to a few more minutes of lecture-based instruction where students learn about how living in space affects bone mass.

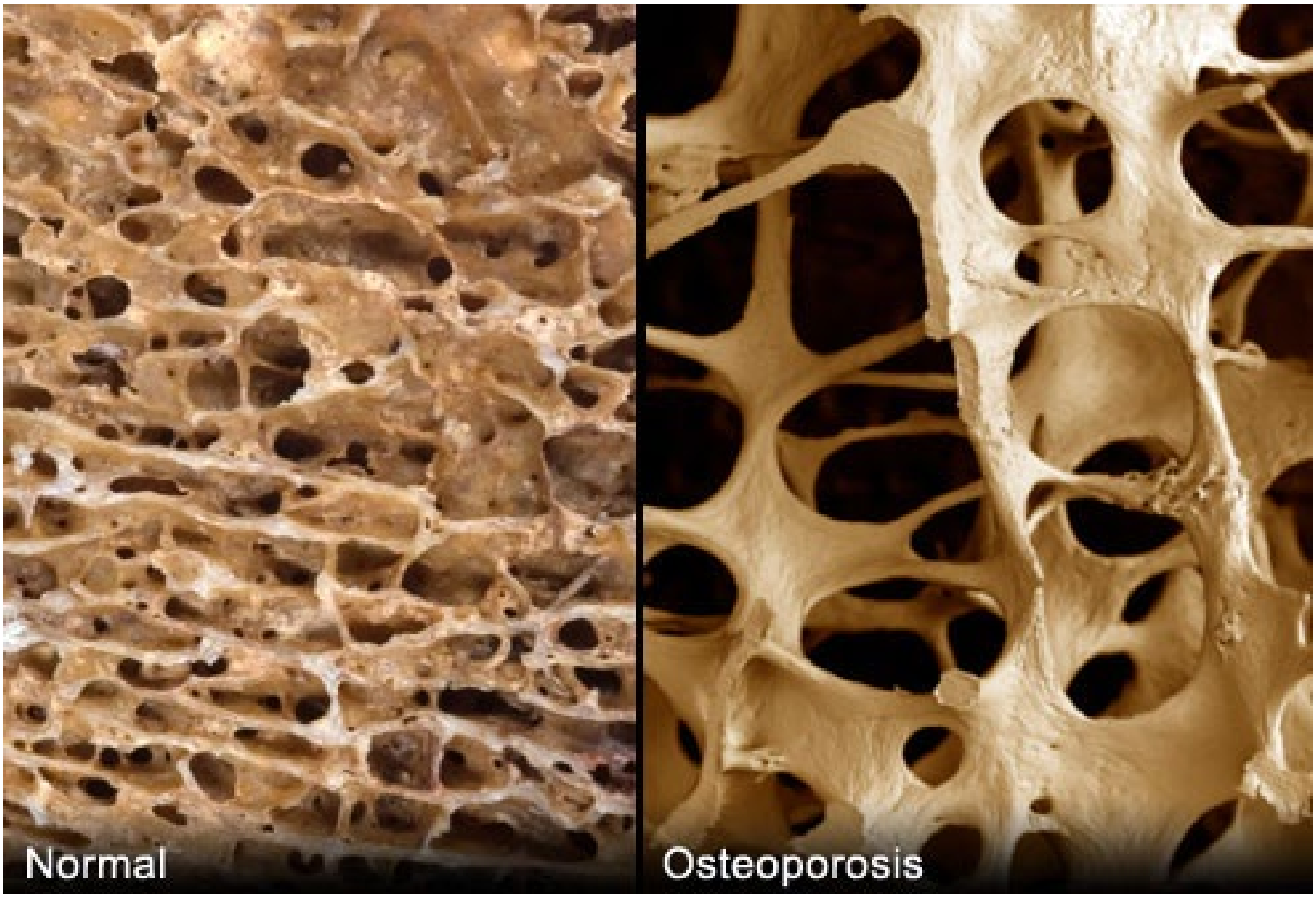
ACTIVITY

Divide the class into several small groups of "astronauts" who are based in a space station similar to the ISS. These students are tasked with trying to fix a broken bone with limited resources (which bone is broken is up to the teacher, but we recommend working with the arm). Tell the students they have about 20 minutes to utilize the materials in front of them and apply what they recently learned to decide how to best secure the broken bone. (OPTIONAL: If it is possible, have students "secure" the unused items using Velcro or masking tape to mimic the idea of being in space/no gravity).

Remind students that bones can be bound in various ways; however a good solution should be to keep the bones secure and immobile. Also remind students that they are in a microgravity environment and to think about how securing a bone in that environment might be easier or more difficult.

After 20 minutes, have one student from each group describe their design to the other groups and explain why they believe it is the best solution to fix the broken bone. In addition, have them describe how they came to their decision. If students are hesitant to share, ask pertinent questions about their decision making process. Examples: I listened to one leader/assumed expert, voted as a group, arrived at general consensus, tried several options, etc.

The lesson ends with a teacher-led class-wide recap and discussion of what they liked about the activity, other group's designs, and a final summarizing point about broken bones in space.



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STUDENT INSTRUCTIONS

You and your teammates are in a space station orbiting the Earth. Due to an unexpected accident, one of your teammates now has a broken arm. This is unprecedented for your team and you all now must design a way to set and fix the broken bone in the microgravity atmosphere. There are limitations and parameters for this situation. Here are a few things to keep in mind as you are working on finding a solution.

- You have limited resources. Only the resources provided by your teacher can be used for this activity.
- There is no right or wrong answer for this exercise. Since this has never been done before no one is prepared for the current situation.
- The only other requirements for the project are the following:
  - The broken arm must be secure (it cannot move at all)
  - The broken arm has to be in a place where it cannot be further injured.
  - The broken arm will continue to be in a microgravity environment for several days. Take this into consideration when finding your solution.

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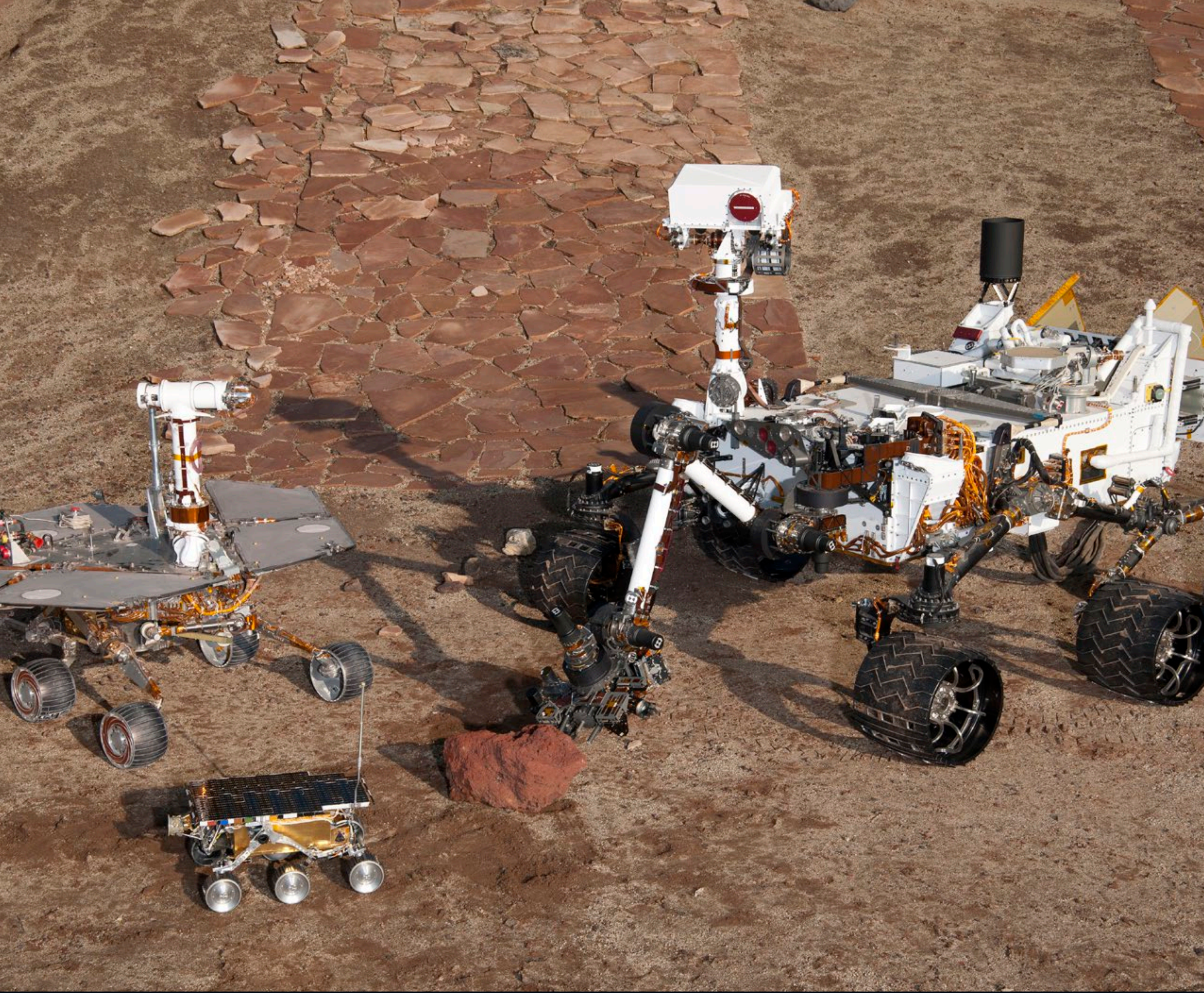

ROVER RACES:
THE SEARCH FOR MINERALS

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THE SEARCH FOR MINERALS

INTRODUCTION

In this lesson, students will be divided into groups of six and tasked with using input commands to drive a “rover” to find valuable minerals, including iron and titanium, on the moon. This task requires a basic understanding of the challenges involved in rover communications, rover operations (programming), and learning about the importance of mining on the moon.

LESSON OVERVIEW

Subject & Grade Level: Science, Grades 5 – 8

Length: 45 minutes (1 full class session); Prep time, 30 minutes

Objectives

At the conclusion of this lesson students will be able to:

- Describe the challenges of remotely moving/operating a rover on the surface of the moon.
- Apply the engineering design cycle to produce a rover that achieves the mission goals within the defined mission constraints.

Key Questions

- How much is the success of engineering contingent upon the communications and operations design?
- How can various proposed design solutions be compared and improved?

Standards

- NGSS MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Common Core MP.2: Reason abstractly and quantitatively.

Materials Needed

- ROV Reproducible 1: 2 per 6-student team
- ROV Reproducible 2: 1 per student team
- ROV Reproducible 3: 1 per student
- ROV Reproducible 4: 1 per student
- ROV Reproducible 5: 1 per student
- ROV Reproducible 6: 1 per student
- ROV Reproducible 7
- ROV Reproducible 8
- 3 blindfolds per team of 6 students (if worried about sanitary conditions, simply ask students to close their eyes when they are the rover)

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- 2 clipboards and pencils per team (1 for each Driver and 1 for each Official)
- Flat obstacles to represent surface rocks (See Teacher Tip in Preparation)
- Laminated (8" x 11") construction paper works well
- Objects to represent titanium and rock samples
- Small traffic cones work well
- 1 stopwatch per team (for use by the team timer)
- 1 set of job cards per team (see Section Preparation, Step A)
- 6 index cards (3x5)
- 1 set of 3 plastic sports cones per team

Facility
- Large flat area to set up obstacle course (classroom, gym, or outside area)

Background Information: Teacher Knowledge

Robots can go places and do tasks that humans cannot. These tasks include things like exploring and mining. Robots do not need air, food or water. However, robots do need step-by-step instructions to perform even the most basic of functions. Robots have been used for space exploration since the inception of the space flight. Today, rovers from multiple nations occupy various planetary bodies throughout the solar system. Rovers are not driven with a joystick or wheel; they are programmed by people on Earth who use cameras on the robots and satellite images to plot out a path for the robot to follow. The act of driving a rover is a laborious process that requires fine programming, planning, and control.

Resources

NASA's Lunar Rover: Everything you need to know
http://www.armaghplanet.com/blog/nasas-lunar-rover-everything-you-need-to-know.html

How do you drive a $2.5 billion Mars Rover?
http://www.space.com/17220-mars-rover-curiosity-martian-driving.html

LESSON STEPS

Preparation

Constructing the Job Cards and Obstacle Course

1. Prepare a set of Rover Races job cards for each rover team. Use 3” by 5” index cards and write the job titles on each card:
   - 1 “Rover Driver” card
   - 3 “Rover Student” cards
   - 1 “Timer” card
   - 1 “Official” card
2. Use pieces of laminated construction paper (or similar) to create the obstacle course for the rovers. The course design can be anything. See (G) Course Setup.
3. Use small traffic cones (or any appropriate item) to represent titanium and iron samples

Warm-up: Rover Driver’s License

Start the activity by having the students brainstorm about how an unmanned robotic vehicle on the moon might be driven. Create a list of ideas.

Have students imagine they are astronauts living on a permanent base on the moon. Ask them why mining would be useful.

Sample Answer: It lets you build new things, you don’t have to bring your materials with you from Earth, it lets you discover new things.

Tell students about titanium and iron. Both of these materials are strong and useful for building. In addition, they can be found in abundance on the moon. Titanium and Iron will be important elements when they fly the Lunar Quest mission.

Activity 1: Explore

Explain to students that rover drivers do not actually use a joystick to direct the rovers. Instead, the mission team creates a series of commands to direct the rover and sends the commands to the rover. This activity will demonstrate some of the complications humans (engineers) must overcome to allow for accurate communication to rovers on the moon.

Inform students that they are going to be looking for both Iron and Titanium. These are two very important minerals that students will be looking for in the Lunar Quest Mission.

Choose, ask for volunteers, or draw names of students to form rover teams. Six students are needed for each team:

1 Rover Driver
3 Rover Students (Each student represents two wheels on a six wheeled rover)
1 Timer
1 Official

The Rover Driver will walk through the course first, counting the number of steps and listing the turns needed to guide the rover through the course (e.g.; 3 steps forward. Stop. 1 step left. Stop. etc.). The driver will use the ***ROV REPRODUCIBLE 1*** to build the list of commands.

Once the Rover Drivers have recorded their command sequences on their ***ROV REPRODUCIBLE 1***, the rover races can begin. The rover teams are lined up at the starting line. Blindfold the three Rover Students to prevent the rovers from aiding the Rover Driver during the command execution. The 3 Rover Students represent the six wheels of a rover and are sequentially in a line (front to back). The blindfolded Rover Students have their hands placed on the student's shoulders in front of them for stability.

Once the Rover Drivers have recorded their uplink sequences on their ***ROV REPRODUCIBLE 1***, the Rover Students will proceed along the course by following the Rover Drivers' verbal commands. The commands cannot be changed from the original commands that the Rover Driver wrote down. They must be followed exactly. During robotic missions, usually the commands are sent up all at once. Any changes have to be made in another uplink of commands later. (If you have additional time and or resources you can utilize technology, like Skype, to have the driver give directions from another classroom out of site.)

The Timers will start their stopwatch as soon as the teacher says "start" and will time until their rover team crosses the finish line. Their time will be recorded on ***ROV REPRODUCIBLE 2/(B) OFFICIAL'S RECORD***.

The Official will use their ***ROV REPRODUCIBLE 2*** to record any time either foot of the first Rover Student touches a Tile on the course (foot faults). The Official will keep a tally of the number of foot faults that their rover team makes. Feel free to remind students that accuracy is always more important than speed.

The cones on the course are titanium and iron samples that can be collected if the Rover Driver has included it on their ***ROV REPRODUCIBLE 1*** sheet. The command would be "Rock Retrieval Right" or "Rock Retrieval Left". At that command, the third Rover Student bends down, and, still blindfolded, sweeps with his or her hand to feel the cone. The student picks the cone up and hands the cone to the second (middle) Rover Student to carry. The second Rover Student then has only one hand on the shoulder of the first Rover Student. The retrieved rock samples give the team extra points upon completing the course.

Activity 2: Explain

Identify Constraints:

Allow time for all the teams to complete the course. Each Rover Team will get together to debrief how the driving went and complete the ROV REPRODUCIBLE 3. This information will include the challenges they faced or observed and their ideas about what might have caused those challenges. They will make a list of the challenges along with the suggested changes for the next drive.

During this time discuss with students how things have gone. Have them describe some of the challenges and successes they found during the first race. What would they do differently?

Activity 3: Elaborate

When teams are finished with their ROV REPRODUCIBLE 3, have students tally the counts on the ROV REPRODUCIBLE 2. The team that has successfully completed the course with the least foot faults, most rock samples returned, and best time is declared to have "mission success."

Repeat the activity as time permits with the second group of students, allowing for the changes the students brainstormed to be included. This iteration will also allow for more students to participate directly. Students will complete their ROV REPRODUCIBLE 4.

At the conclusion of the activity, read the following to explain and tie up all of the Engineering concepts introduced and experienced in this activity:

What you have just experienced is a lesson on engineering and how we communicate with a rover on another planet. Engineering allows us to solve human problems using science and technology. In this case, you found quite a few problems on your first round. Give me a couple of examples.

Examples students might note:

- Our steps were not the same, so we had to adjust.
- Moving three people is harder than moving one.

These are examples of calibration. Calibration means that you need to make adjustments to create a standard. For example, you adjusted the length of your step to a standard length for everyone in your group.

The engineering design cycle includes identifying a problem, specifying constraints (limitations) and criteria for the desired solution, developing a design plan, producing and testing models (physical and/or computer generated), selecting the best option among alternative design features, and redefining the design ideas based on the performance of a prototype or simulation.

(A) Student Worksheet. Rover Driver Command and Information Sheet

Name____ Date_________________

1. Walk through the simulated moon surface obstacle course. Write down the commands the rover should follow. Count your steps and be sure to list where the rover needs to make a turn on the course.
2. When the rover is in the correct position to retrieve a rock, you may ask the last person in the rover to pick up the rock for bonus points. Use the command "Rock Sample Retrieval Left" or "Rock Sample Retrieval Right."
3. The rover will only be able to follow your set of written commands. The commands to the rover cannot be any different from what you have written.

Rover Commands:

Right (R)	**Left (L)**
Backward (B)	**Forward (F)**
Stop (S)	**Rock Sample Retrieval (RSR)**

Commands: (Example: 1. Forward 3 steps. Stop. 2. Turn left 1 step. Stop…….)

1.	11.
2.	12.
3.	13.
4.	14.
5.	15.
6..	16.
7.	17.
8.	18.
9.	19.
10.	20.

(B) Student Worksheet. Official's Record

Name____ Date_________________

Make a counting (tally) mark (example: lll…) every time the first person in your rover team steps on a tile (simulated moon surface). These are called foot faults. Keep track of these foot faults through the entire course, and count the marks to make a total after your rover team crosses the finish line.

NAME OF ROVER DRIVER:

____

NAME OF ROVER TEAM OFFICIAL:

____

NAME OF ROVER TEAM TIMER:

____

TOTAL FOOT FAULTS (steps on tiles by first person in rover):

____

TOTAL TIME FOR ROVER TEAM TO COMPLETE COURSE:

____

TOTAL TITANIUM SAMPLES COLLECTED:

____

TOTAL IRON SAMPLES COLLECTED:

____

(C) Student Worksheet. Rover Team Evaluation – First Race

Name____ Date__________________

As a class, complete the following after your Rover Team has completed the first round of Rover Races.

1. Brainstorm some of the challenges you experienced during your first Rover Race and the potential causes of these challenges.

2. What are the suggested changes for the Rover Team's next drive?

(D) Student Worksheet. Rover Team Evaluation – Second Race

Name____ Date_______________

As a class, answer the following questions after the Rover Team completes the second round of Rover Races.

1. Which changes worked well and why?

2. Which changes did not work well and why?

3. If you could do a third race, what changes would you use to make your Rover move where you want it to go?

Name ____ Date ________________

Identifying a problem: Name at least 2 problems that needed to be solved for the team to develop successful communication to your rover.

1. ____

____

2. ____

____

Specifying constraints (limitations) and criteria for the desired solution: What were some of the requirements (constraints and criteria) you needed to consider for your solutions? For example, worked for all 3 student rovers, not just for 1 person.

____

____

____

____

How many different options did your group identify to solve this particular problem? Which did your group choose and why?

____

____

Redefine the design ideas based on the performance of a prototype or simulation:

____

____

After your group tried out the new design to solve the problem, did it solve the problem? What new changes would you try to make this solution better?

____

____

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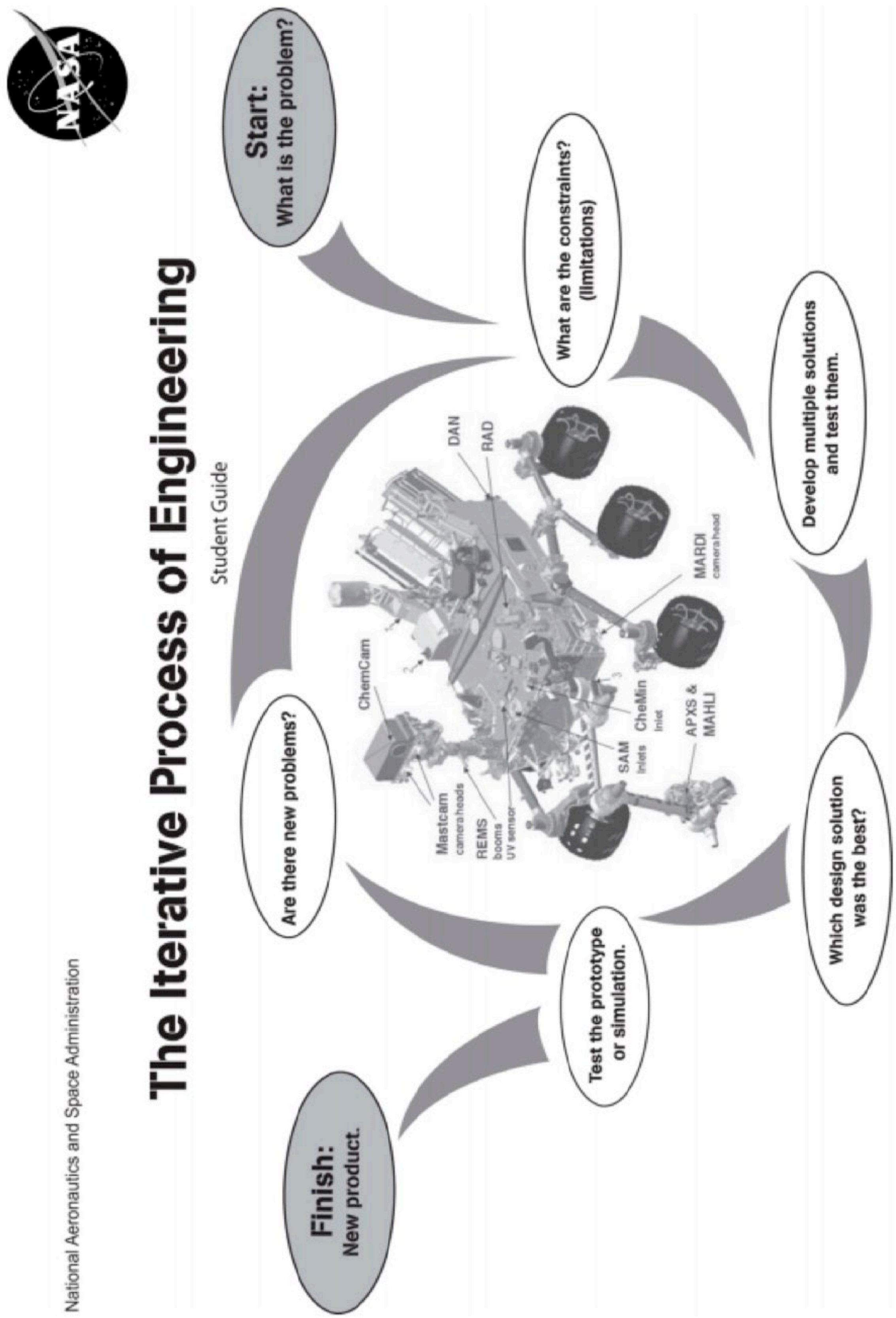
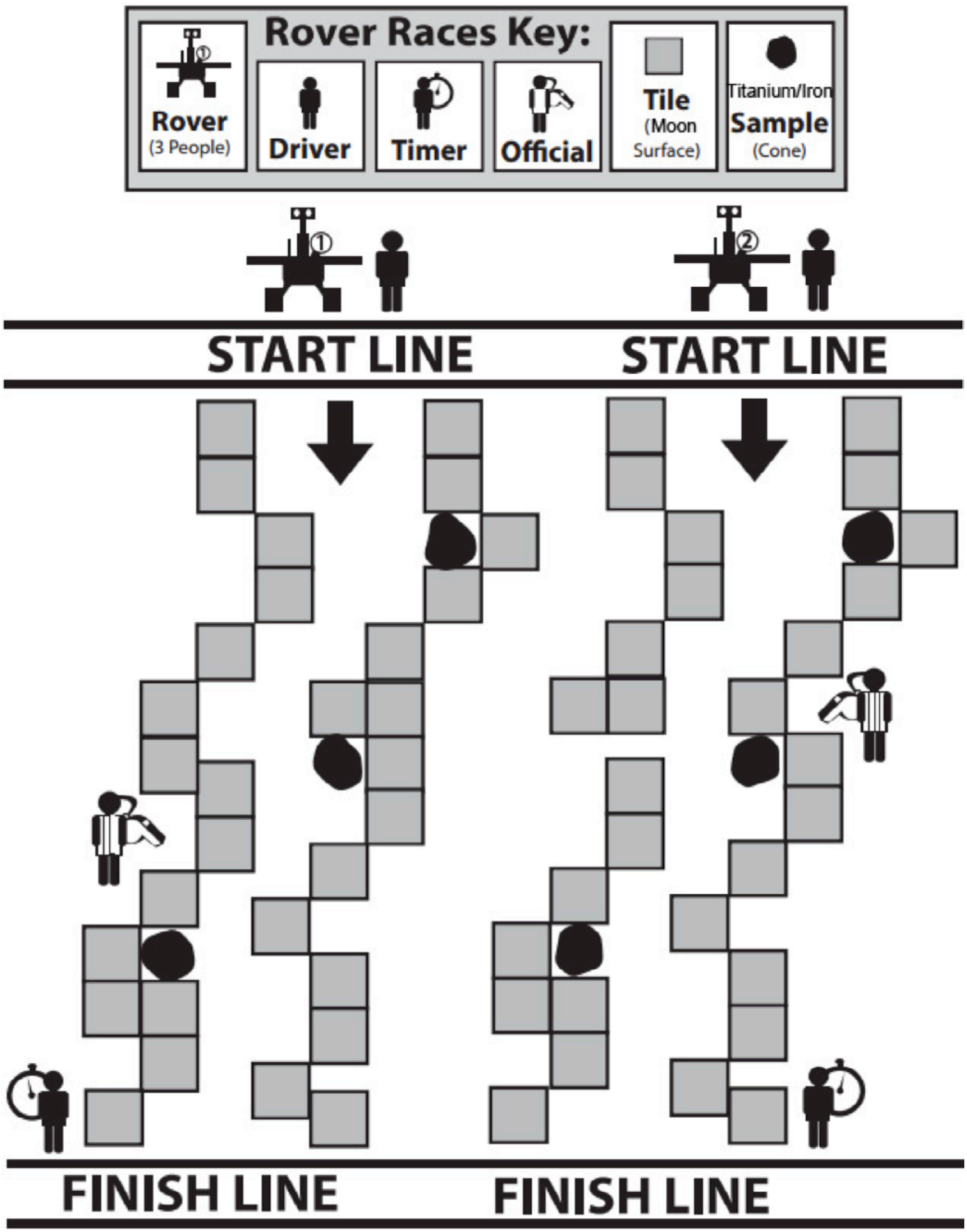
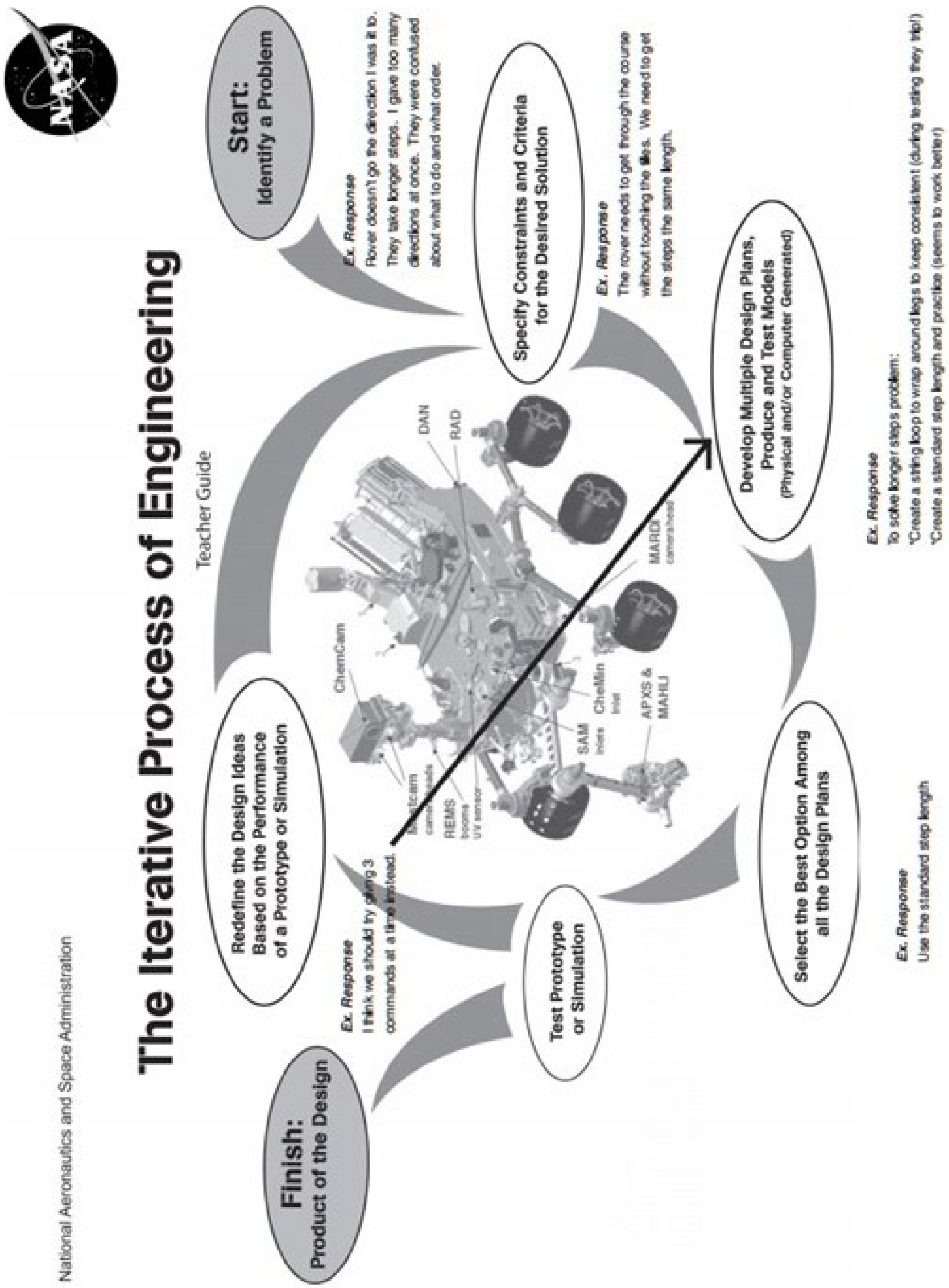
ROV Reproducible 6: Iterative Process of Engineering



FOR TEACHER USE
ROV Reproducible 7: Course Set up Example:



FOR TEACHER USE
ROV Reproducible 8: Iterative Process of Engineering Key:
(OPTIONAL)



ORBITAL MECHANICS: LANDING ON THE MOON

ORBITAL MECHANICS:
LANDING ON THE MOON

INTRODUCTION

In this lesson, students are divided into small groups to work together to try and successfully land a valuable “payload” on the moon. The small groups are responsible for the safe passage of the valuable item and are given the full authority to select a landing angle. In this simulation, students are trying to figure out the best way to safely land an object on the moon.

LESSON OVERVIEW

Subject & Grade Level: Science, 5 – 8 Grade

Length: 60 minutes

Objectives

At the conclusion of this lesson students will be able to:

- Construct rovers that can land intact closest to the landing zone.
- Analyze and conclude what makes the best landing rover.
- Reproduce basic physics knowledge through quality air ship designs.

Key Questions

- Why do we not fly straight to where we see the moon?
- What is the most effective way to land an unmanned vehicle?
- What forces allow a rover and rocket to move?

Standards

- NGSS MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- NGSS MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- NGSS MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Common Core MP.2: Reason abstractly and quantitatively.

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Materials Needed:

Each group of 4 to 5 students will need the following item to complete this lesson.

- OM Reproducible 1
- 2 large sheets of cardboard (boxes from the cafeteria will suffice)
- 1 small rock/egg (about the same size, teacher's choice if you want it to be messy)
- 1 roll of duct tape
- 10-15 wooden unsharpened pencils
- 2 (8" x 11") sheets of construction paper
- 10-20 cotton balls
- 1 bottle of glue or glue stick
- 1 bandana/piece of cloth
- 2-3 balloons
- 1-2 plastic soda bottles
- 1 roll masking tape

Background Information: Teacher Knowledge

Trying to leave our atmosphere is not as easy as it sounds. Trying to land when returning is sometimes even more difficult. In both of these examples several differing equations are calculated to ensure that the astronauts and their cargo is kept safe throughout the entire process.

For many years, the main system of returning to Earth was varying kinds of drag chutes and parachutes that slowly lowered the capsule. On the moon this is not possible because of the lack of atmosphere. Since there is no atmosphere, the parachutes would not be useful as they cannot be used in correlation with air resistance.

Another way to land on the moon or land on Earth is the idea of powered descent. In this technique, the ship or capsule utilizes rockets to slow itself down before quietly touching down on the surface. This was the technique utilized by the Apollo missions in the 1960s and 1970s.

The final example is the technique of lithobraking. Lithobraking, demonstrated in this lab, is the act of absorbing all of the kinetic energy and dispersing it through direct impact. To ensure the survival of the object, it is usually covered in a series of airbag-like devices that act as cushions for the landing. This technique was most recently explored during the Mars missions, and a similar technique to modern day lithobraking was utilized in the moon missions.

In the 1960s, Ranger missions to the moon utilized a different type of lithobraking because of the mission's focus. The Ranger missions were focused on what could be done prior to impact on the moon's surface. On the other hand, the recent Mars missions focused on payload survival and the ability to continue exploration.

Resources

Orbital Spaceflight
http://www2.jpl.nasa.gov/basics/bsf3-4.php

Lithobraking
http://en.wikipedia.org/wiki/Lithobraking

Historical Moon Landings
http://science.howstuffworks.com/apollo-spacecraft6.htm

http://airandspace.si.edu/explore-and-learn/topics/apollo/apollo-program/landing-missions/apollo11.cfm

http://science.nasa.gov/missions/ranger/

http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1969-059C

https://www.youtube.com/watch?v=RMINSD7MmT4

LESSON STEPS

Teacher Preparation

To prepare for this lesson, teachers must have reviewed the basic resources and created the basic “target” for their students. Teachers will create this target using masking tape to mimic a bullseye. This will be what students will aim for when they attempt their different designs. Teachers need to prepare all of the above mentioned materials. It might be easier if students were given a box/basket that contained all of the materials so everything can be easily prepared.

Warm-Up

Divide the class into groups of 4 to 5 students

Show the following video (https://www.youtube.com/watch?v=RMINSD7MmT4). Pause the video interminably (about every 15 seconds). Have students analyze what they are seeing and what they think they are seeing in each segment. (Utilize OM REPRODUCIBLE 1 to guide their talking points). Accuracy is not important in their responses, but active analysis and participation is key.

Show Image 1 from OM REPRODUCIBLE 2 on the screen and provide another 30 seconds to analyze.

Have a larger group discussion sharing everyone’s input about what they think is going on and why it is happening.

A few sample questions to help guide the discussion:

What is going in this video?

What do you think we are discussing today?

When do you think this happened/happens?

Where are the men located?

How do you think they got to this location?

This leads into a brief discussion-based learning period where all the answers above are given definite answers. (For example: What is going on in this video? Man is on the moon’s surface for the first time.)

Activity

At this point, explain to the students that their task is to continue following in the footsteps of these men. Their simulation is a little different however. There is already a base on the moon, they just need to get supplies to the group. Create a rover that will land and maintain functionality through the lithobreaking landing technique. (Example can be shown with OM REPRODUCIBLE 2)

They must create a rover that can carry the rock/egg provided and will land safely on the bullseye. (Additional instructions included on OM REPRODUCIBLE 1)

After giving the students a small amount of time to build their object, each group will come up one at a time and test their rover with the "landing vehicle" (the bucket) to attempt to land it on the bullseye. Measure and make note of how close each rover landed, as well as how intact it was when it landed.

After each group has attempted their landing, have a brief class discussion about what they saw and have students write down on the back of the worksheet three things they learned from today, two things they would do to improve the design, and one thing they liked about another design that they would use in the future.

Name____ Date_________________

Orbital Mechanics: Landing a Rover

In today's lesson you will be responsible for designing and landing your own rover on the moon. You will have limited resources and only one attempt at landing, so be sure you think through your plan very carefully.

Information Gathering

Look at the two images your teacher displays. Within your group, discuss the following questions:

1. What is taking place on in this image? and why?
2. What shapes do you see in these images?
3. How do these two images relate to what we are going to do in class? (make a guess if you do not know)

Information into Action

You will be designing a rover that will have to carry the provided rock as well as land safely on the landing pad (the bullseye). You will have 15 minutes to work with your group to brainstorm and create the best design. Here are a few things to keep in mind:

1. Is the valuable mineral (the rock) secure and immovable?
2. Will the rover still be functional after it falls below?
3. How can you angle the bucket during launch to get the best angle for your rover?

Materials to Build Your Rover

- 2 large sheets of cardboard (boxes from the cafeteria will suffice)
- 1 small rock/egg (about the same size, teacher's choice if you want it to be messy)
- 1 roll of duct tape
- 10-15 wooden unsharpened pencils
- 2 (8" x 11") sheets of construction paper
- 10-20 cotton balls
- 1 bottle of glue or glue stick
- 1 bandana/piece of cloth
- 2-3 balloons
- 1-2 plastic soda bottles
- 1 roll masking tape

-continued on page OM 6-

Conclusion: What did you learn?

Write three things you learned today:

Describe two ways you would improve your team's design:

Describe one idea that you would borrow or use from another team's design in your future models:


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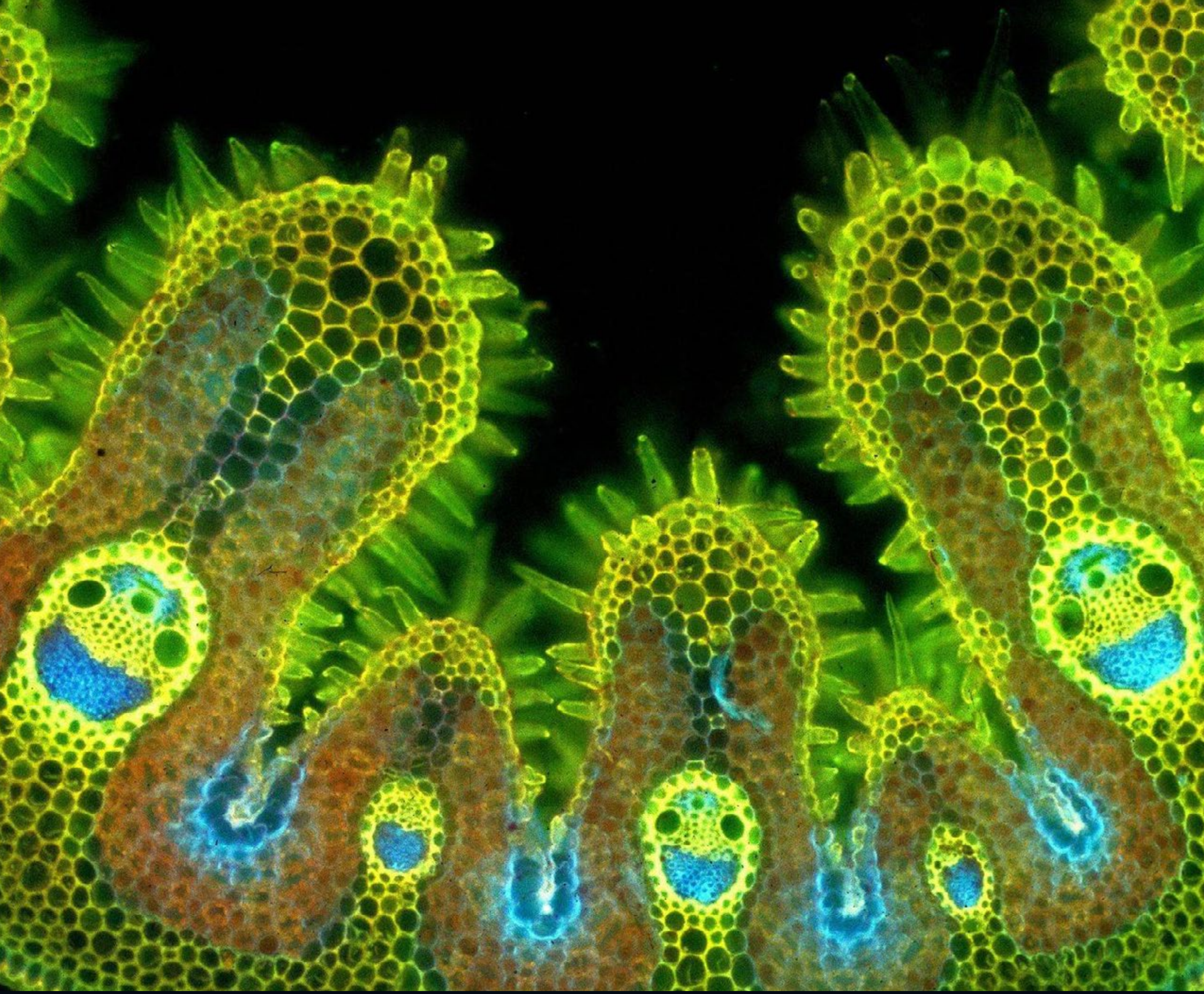

THE SEARCH FOR LIFE

THE SEARCH FOR LIFE

INTRODUCTION

In this lesson, students learn about the habitual zone for planets and how to search for new life in the universe.

LESSON OVERVIEW

Subject & Grade Level: Science, 5 – 8 Grade

Length: 30 minutes

Objectives

At the conclusion of this lesson students will be able to:

- Illustrate the conditions necessary to discover life on other worlds.
- Decide which planets are best suited and most likely to carry life
- Connect similarities between the Earth and other planets listed.

Key Questions

- What are the necessary conditions needed for life as we know it?
- Why is there not life on all of the planets in our solar system?

Standards

- NGSS MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- CC WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- CC MP.2: Reason abstractly and quantitatively.

Materials Needed

- SFL Reproducible 1
- SFL Reproducible 2
- Internet accessibility / ability to play a video from the internet

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Background Information: Teacher Knowledge

The search for life in our universe begins here on Earth. We examine what life needs to survive on Earth and try to find places in the universe that have those characteristics. Planets outside of our solar system that have those characteristics would be considered places where we might find life similar to life on Earth or "life as we know it". Those characteristics include the size of the planet, whether or not it has an atmosphere and how far away it is from the star it orbits.

Resources

Conditions that Support Life
http://learn.genetics.utah.edu/content/astrobiology/conditions/

Europa & Titan: Moons with Life?
http://earthguide.ucsd.edu/virtualmuseum/litu/10_3.shtml
http://www.nasa.gov/ames/kepler/nasas-kepler-discovers-first-earth-size-planet-in-the-habitable-zone-of-another-star/#.U8A5gZRdVg0

Discovering Exoplanets
https://www.youtube.com/watch?v=GDtPnK9sJ5s
https://www.youtube.com/watch?v=zFPnOUSdMdc
http://kepler.nasa.gov/

LESSON STEPS

Teacher Preparation

To prepare for this lesson, teachers must be familiar with the basic background information. This basic information can be read or heard through the various links above. Teachers should ensure that a solid internet connection is available in the classroom. Load the videos beforehand so that you can dodge buffer issues and advertisements. Make sure that all students have a copy of the attached charts.

Warm-Up

Divide the class into small groups of four to five students.

Allow students a few minutes to brainstorm their ideas and/or share with others in their group about the following questions: What constitutes life? What are the conditions for life?

Students will nominate one student within their group to share their ideas to be recorded on the board by the teacher or to be displayed for all to see on a dry erase board or electronic tablet.

After a brief discussion about what the students believed, watch the following short video as a group. Have students individually write down three things they learn from the video on a scratch piece of paper (TED ED video on the habitable zone).

Ask students:

What makes Earth a good place for life?

Answers should include things such as the gravity on Earth, the atmosphere and distance from our sun.

Activity

Hand out SFL REPRODUCIBLE 1 and SFL REPRODUCIBLE 2.

Students will utilize the descriptions to assist in filling out the table and formulating conclusions.

Walk students through the top planet (Earth) in the Conditions for Life Table.

Have students work through the rest of the table on their own.

Once students have finished, review the table one planet at a time to discuss the conclusions and the reasoning behind conclusions.

To conclude the lesson, make sure to remind the students that the activity they performed today was merely an estimation. Inform them that these charts and tables are the best resources we have to try and formulate our conclusions.

Size of the Planet ($M_{\oplus}$)

If a planet is too small, it cannot hold onto an atmosphere and will become too cold or too hot. If a planet is too large, deep ocean water could freeze and stop the planet's flow of life. Large planets also have large amounts of gravity, and too much gravity could make life impossible.

Planet size, in relation to Earth, is measured in a unit called Earth Masses $\mathbf{M_{\oplus}}$.

Earth = 1 Earth Mass
Mars = .3 Earth Masses smaller than the Earth

A planet that can support life as we know it would have an Earth Mass between **.03** and **2**.

What is in the atmosphere?

The make-up of an atmosphere is an important factor when trying to decide if life can exist. We look for gases similar to those we have on Earth.

These gases include **Nitrogen, Oxygen, Water** and **Carbon Dioxide**.

Not all potentially habitable planets need all of these gases, but the more gases there are, the more likely life becomes.

Is there an atmosphere?

Atmospheres regulate temperatures; oceans freeze or boil without an atmosphere to protect them. Life as we know it needs an atmosphere.

AU (Distance from the Sun)

The distance between our Earth and the sun is about 149 million kilometers. We call that distance an Astronomical Unit (AU).

1 AU is the distance between Earth and the sun
2 AU is twice the distance from Earth to the sun
.5 AU would be half the distance between Earth and the sun

For life as we know it to exist, a planet must be located somewhere between **.5 AU** to **1.688 AU** from its star.

Name____ Date________________

Planet Name	**Planet Size ($M_{\oplus}$)**	**Is here an Atmosphere?**	**What is in the Atmosphere?**	**AU (distance from Sun)**	**Is there Potential for Life?**
Earth	1	Yes	Nitrogen, Oxygen, Carbon Dioxide, Methane	1.0	
KOI – 4356.01	.25	No	-	2.2	
Gliese – 581 G	1.1	Yes	Carbon Dioxide, Nitrogen	.72	
Kepler-186f	1.2	Yes	Nitrogen, Water, Carbon Dioxide, Methane	1.4	
KOI – 1686.01	.32	Yes	Carbon Dioxide, Argon	1.38	
Tau Ceti e	317	Yes	Helium, Hydrogen	4.95	

SFL Reproducible 2: Answer Key

Planet Name	Planet Size ($M_{\oplus}$)	Is here an Atmosphere?	What is in the Atmosphere?	AU (distance from Sun)	Is there Potential for Life?
Earth	1	Yes	Nitrogen, Oxygen, Carbon Dioxide, Methane	1.0	**Yes**
KOI – 4356.01	.25	No	-	2.2	**No**
Gliese – 581 G	1.1	Yes	Carbon Dioxide, Nitrogen	.72	**No**
Kepler-186f	1.2	Yes	Nitrogen, Water, Carbon Dioxide, Methane	1.4	**Yes**
KOI – 1686.01	.32	Yes	Carbon Dioxide, Argon	1.38	**No**
Tau Ceti e	317	Yes	Helium, Hydrogen	4.95	**No**