The Space Microbe Invasion: To Eat or Not to Eat?

Objective: To investigate how different cleaning agents sanitize an assortment of vegetables and fruits for consumption on board the International Space Station (ISS).

Description: This laboratory investigation will have students testing different cleaning agents on a variety of vegetables and fruits that can be grown on board the ISS. Students will determine which cleaning agent most effectively lowers the number of bacteria on a variety of vegetables and fruits. This lab will also lend itself to investigations dealing with pH and its role in lowering bacterial counts. In addition, students will figure out the correct balance between plant architecture and effectiveness of sanitizing these surfaces to achieve lower bacteria counts. This will be determined based on swabbed bacteria samples later grown on a Petri dish.

Science Standards (Includes CCSS & EOC standards):
SC.912.N.1.1- Define a problem based on a specific body of knowledge, for example biology: Pose a question, conduct systematic observations, examine sources for information, plan investigation, use tools to gather, analyze, and interpret data, pose answers, explanations, or descriptions of events and communicate results of scientific investigation and evaluate the merits of the explanations produced by others. *(CCSS Connections for 6-12 Literacy in Science)*
SC.912.N.1.7- Recognize the role of creativity in constructing scientific questions, methods and explanations.
SC.912.L.14.7- Relate the structure of each of the major plant organs and tissue to physiological processes. *(Tested annually on the EOC)*
SC.912.L.17.20- Predict the impact of individuals on the environmental systems and examine how human lifestyles affect sustainability *(Tested annually on the EOC)*
SC.912.L.14.52- Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics. *(Tested annually on the EOC)*
SC.912.E.5.9- Analyze the broad effects of space exploration on the economy and culture of Florida.

Science Process Skills:

Observing	Collecting Data	Controlling variables
Communicating	Inferring	Making Graphs
Measuring	Investigating	Interpreting Data

Optional Lesson Enhancement: The Space Microbe Invasion Lesson Video Component
The video lesson adds a new level of realism and connects students directly to NASA and the content being taught. This video highlight a microbiologist working at NASA on the same issues related to microbes in space that the students will be working on. The introduction will capture students' interest by presenting a problem in a humorous manner which will lead them meeting the microbiologist that will provide a brief explanation of the work they do. The video best works by showing this first to the students and allowing the microbiologist to invite them to solve the issue of microbes in space and is later on played once the students have completed the lab. In the second half of the video the microbiologist present questions and ideas related to the questions found at the end of the lesson which serves to further help students understand the challenges scientist face.

Management:
All students will be working simultaneously on this lab investigation and consequently all materials will be shared by classmates. Students will be working in teams of four (can vary if necessary) where they will each be assigned a role with specific responsibilities. The students will be deciding what vegetables, fruits, cleaning

agent, and method of application; they see most fit for their specific investigation. Each student and class as a whole will choose their own section of the room in which they will be able to leave their experiments over the next few days. This investigation will take anywhere from 4 to 7 days to execute depending on how many days you want to allow the bacteria to grow, as well as how much time is dedicated to student research time. Note only 3 days will have instruction while the other days are 5 min observation days.

Materials and Tools (per lab station):

- Assortment of vegetables/fruits (onion, apple, broccoli, lettuce, beet, zucchini, orange, pepper).
- Assortment of cleaning agents (lemon juice, vinegar, regular water, dish washing detergent)
- Cotton swabs (6)
- Scotch tape
- pH Strips
- Paper towels
- Paper plates
- Zip lock bags (3)
- Pre-prepared agar filled Petri dishes (6)
- Scalpel/small cutting device
- Bifocal Microscope
- Student handout/record sheet

* These items will be located on the teacher's work table and students will take what they need.
* Note vegetables and fruits may be precut to save time and resources. In addition, sample cups or beakers may be placed in front of the cleaning solutions to have students test pH, which will further save on resources.

Background Information for Teacher: In this investigation students will learn about some of the difficulties astronauts face when living and working in space on board the ISS. Students will work in teams to problem solve issues regarding the microbes space invasion. This lesson is presented in an inquiry based format because students will be left on their own to design an approach for not only cleaning vegetables and fruits in space, but also deciding which are the best to go up based on the amount of microbes they may naturally retain or the difficulty faced in keeping microbes off of them. In addition, students will be asked thought provoking question in the assessment portion regarding their discussion for choosing a particular cleaning agent, method and vegetable or fruit. Students will be forced to reflect upon the decision made and judge whether or not they accurately solved the problem of lowering the bacteria count while also considering the unique environment of microgravity.

Background Information for Students (to be read aloud by the teacher): Astronauts have been living and working onboard the International Space for over 12 years! This unique science laboratory orbiting 220 miles over earth offers scientist many opportunities to learn about the formation of crystals, chemical reactions, physics, biology and so much more! Scientist take up payload from earth, study it in space and bring it back down and analyze the affects brought upon by microgravity. However, sometimes some things are left behind and when they do they multiply! Any idea what they are? Microbes! Also known as bacteria! Ever since astronauts have been in space, so have the microbes they have brought up with them! Generations of space microbes hitching a ride to and from space, living on the astronauts and yes living in the astronauts! How do they get there? What does this mean?

Procedures:
Refer to the Student Handout

Post Lab Answers:

1. Students should be able to identify the independent (cleaning agent and food item used) and dependent (bacteria growth) variable.
2. Student questions will vary, but they should be able to see differences in the amount of microbes growing on the petri dish of the control verses the experiment. If their cleaning agent was useful there will be less bacteria growing on the experimental petri dish as opposed to the control; and if not, the opposite is true.
3. Students should try to focus on groups that used food items liked theirs but different solutions to be able to isolate the cause(s) for differences they may notice. If no other groups used the same food item they should write that in their response to reflect this level of understanding.
4. Student answers should be set up similar to the answer above.
5. Student questions will vary, but they should write a comprehensive analysis of their findings by first comparing their results to others. They should compare how the structure/ architecture of the food items along with the pH levels of their cleaning agents lower and or did not lower the amount of microbial growth on their experimental variable as opposed to the control.

Extended Response Answers:

1. Students should analyze their methods and recall the effects of microgravity on liquids and other items to determine if their experiment is repeatable in space. If not they should offer possible modification (a design review).
2. Students should at this point think about the whole size of their food items. For instance if students chose apples and oranges they should now realize there is no space to grow trees on ISS. However, if students chose small vegetables that requires little water and so on because they did analyze this prior they can now explain why they made a good decision.
3. In this portion, if you as the teacher have already covered the plant unit you can have your students' responses be more specific, but if you have not cover this part you can use this to see what they know. Regardless, student should be familiar with general parts of plants, and should name them, and realize that the more areas that are swab the more microbes they may find. In addition, certain parts of the plants may contain more microbes such as the roots that come in contact with water and or other materials.
4. Student responses may vary but they should mention that research opens up opportunities for new jobs which helps increase the economy. New technologies in the area of food production has the potential to change how food is grown in Florida as well as other places, and teaches people how to produce a greater amount of nutritious food with fewer resources. In addition, if these new technologies help to assist people in living long term in space and or another celestial body this will have major impacts in all cultures.
5. In section a. students should list possible reasons for an increase in the microbe population. This question is designed to get them to further think about barriers and obstacles that go into designing this project, as well as using their background knowledge and or research more on bacteria to answer this question. The list may include possible contamination from the crew; one type of bacteria could have died out causing another one to grow exponentially, trouble with the water system which can cause plants to stress etc. In section b. students can describe how the body responses to an infection.

Depending on how much of this has already been taught in class or if you as the teacher would like to use this section to introduce or enhance the unit on the immune system, you can have students describe in detail how microbes can enter the body and how they can infect their host. For example, they can explain how the microbes could have by past the first line of defense (the skin) because an astronaut got a cut and from that point students can describe what the body does to attack foreign invaders.

Optional videos to Enhance Lesson:

- "*Preparing Bacteria Samples*"- http://www.youtube.com/watch?v=6-chXVgu8Z0 This 4 minute long video shows Steve Spangler quickly demonstrating how to prepare petri dish samples and the possible results you may get. The video can be used to get students thinking about how bacterial are everywhere and the problems astronauts face because of lack of running water.
- "*Benefits of Growing Bacteria in Space*" - http://www.youtube.com/watch?v=wQNTs6RmJoM This 2:26 minute video shows clips of astronauts working in space and is narrated by a man explaining why scientists bring bacteria into space and the benefits of doing so. This can be used to answer the standard related to the impact that space research has on our culture and how humans impact their environment.

- "*Sampling Air Microbes in Space*"- http://www.youtube.com/watch?v=oJL2f8SpWhU – In this 2:46min video astronaut Chris Hadfield samples microbes in the air of the international space station and shares some results from surfaces that were swabbed. This can be used as further proof that there are currently microbes on board the ISS.

- "Surface Tension in Space"- http://www.youtube.com/watch?v=o8TssbmY-GM – In this 3:19 minute astronaut Chris Hadfield tests the surface tension of a wet wash clothes. A good video to show students how difficult it would be to clean surfaces on space due to the behavior of liquids in microgravity

Name: _____ Period: _____ Date: _____

Student Handout/Record Sheet For:

The Space Microbe Invasion: To Eat or Not to Eat?

Problem:

Microbes on board the International Space Station have been living there for years and for the most part astronauts have been ok sharing their 'space' with them. However, now there is a problem! As NASA gets closer and closer to achieving its mission of traveling further into space, to a nearby asteroid, Mars and beyond, scientist and engineers must find new ways to provide a continuous source of food! What is a good way of getting the job done? (Stop and think…) If you guessed growing plants as a source of food you are correct! However, this is one of the problems scientist and astronauts face when growing plants in space. It turns out the microbes love the plants too!

Your Mission: Remove the MOB (Microbes On Board):

Your mission is to find the best sanitizing solution and the best vegetable(s) and or fruit(s) to consume in space. All food items are not made the same. Choose wisely when deciding what vegetables or fruits may make or not make good homes for microbes.

Student Teams: Each student shall assume the role of NASA personnel and take on those responsibilities to insure everyone works as a team to solve the problem of the microbes growing on the food of the astronauts.

Positions: (All positions are equally important and team effort is required to insure overall success)

Project Manager: This person will assume the responsibilities of making sure all the work gets done and writing up the results. Help your fellow classmates stay on task and lend a helping hand when needed. Conduct progress report meetings to insure everyone is working together and solving the problem correctly. Create a schedule to insure all necessary work is conducted on a timely manner.

Principle Investigator (P.I) A: This person is a scientist and the subject matter expert on plants. You are responsible for being knowledgeable about the plants (vegetables/fruits) being used. Research what vegetables/fruits are best for the astronauts to consume based on nutrition. However, make sure to look at the surface of the food item under the microscope to decide which one would be easiest to clean. You choose the vegetables/fruits for this experiment.

Principle Investigator (P.I) B: This person is a scientist and the subject matter expert on microbes. You are responsible for being knowledgeable about the procedures involved in preparing Petri dish samples of bacteria and monitoring their growth. Research literature on bacterial growth in space and what solutions work best to sanitize the vegetables. You choose the cleaning solutions for this experiment and record pH levels.

Project Scientist: This person will help both Principle Investigators (P.Is) with subject matter expertise and integrating both projects together. In addition, the project scientist will help with structural support and monitor that all aspects being perform in the class are repeatable in space. Hence be mindful of the effects of microgravity and help construct materials/procedures that are repeatable in space.

Assigned Positions:

Project Manager: _____

Principle Investigator A: _____

Principle Investigator B: _____

Project Scientist: _____

Materials and Tools (per lab station):

- Assortment of vegetables/fruits * (onion, apple, broccoli, lettuce, beet, zucchini, orange, pepper).
- Assortment of cleaning agents * (lemon juice, vinegar, regular water, dish washing detergent).
- Cotton swabs (6)
- Scotch tape
- pH Strips
- Paper towels
- Paper plates
- Zip lock bags (3)
- Pre-prepared agar filled Petri dishes (6)
- Scalpel/small cutting device
- Gloves
- Bifocal Microscope
- Student handout/record sheet

* These items will be located on the teacher's work table and students will take what they need.

Day 1 Procedures:

1. Determine student teams and assign positions.
2. As a team walk up to the lab table containing all the materials. Observe what materials are available to you and then return to your seat with your team and begin to discuss how you will solve the invasion of the space microbes. Record your thoughts and observations in the space provided below.
3. Use the time, allotted by your teacher, in class to conduct the background information and research necessary for you to succeed at solving the big small problem. Use your resources, whether they are your books, science articles, web resources and previous knowledge.
4. Write down under the heading "Research Information/Supplies" what you researched and what supplies your team has decided to use to conduct the experiment first thing tomorrow.
5. Answer questions A & B

Day 1 Thoughts & Observations:

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Research Information/Supplies:

A. What is your question/hypothesis for this experiment?

B. What is your plan for this investigation?

Day 2 Procedures:

1. Regroup with your team members and once again assume your roles. Project Managers, quickly recap yesterday's research results and what supplies your team is using. If required the P.Is will once again state why they have picked those specific supplies.
2. Gather your supplies at your lab table/desk and wear gloves
3. Project scientist student go over the best methods for gathering data based on microgravity constraints.
4. Perform data collection. This will differ based on your chosen methods and criteria. Regardless your procedures should resemble something such as the following:
    a. Cut 2 sections from each of your food items and proceed to handle one as your control and other as a part of your experimental design.
    b. Take your control and obtain a sample of microbes by taking a cotton swab and streaking it across the petri dish in a zigzag manner or by applying a small piece of tape over an area of the food item and lifting off a microbe sample.
    c. Cover and label each petri dish with a permanent marker (include team name and what you sampled). Tape down two sides of the petri dish to ensure the cover cannot be removed and or further contaminated.
    d. Next take the cleaning solution that your team determined ideal for cleaning food items in space and clean your food items with the method identified by your project scientist. With the

determine method for cleaning (i.e. dipped in the solution or wiped with a paper towel soaked in the solution etc.) proceed to clean each of your experimental food items.

e. Wait approximately 2 minutes after cleaning your food and take a microbial sample with the same method that you use with your control.
f. Cover and label the experimental petri dishes the same way you handled the controls.
g. Pick a safe and secure area of your classroom where you can leave the petri dishes undisturbed for the next few days.

5. Record your day 2 thoughts and observation in the space provided.
6. Project managers meet with the teacher to discuss what your team accomplished thus far. Take care of any concerns and action items (things that need to be accomplished) set forth by the teacher.

Day 2 Thoughts & Observations:

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Day 3 Procedures:

1. Check on your microbial samples and document and draw below what you see.
2. On a separate sheet of paper create a graph (on excel or graph paper). Label your X and Y axis and chart the growth of your microbes for both your experimental and control group. You decide what the best graph to present your findings is.

Day 4 Procedures:

1. Check on your microbial samples, graph data collected, and draw below what you see.

Day 5 Procedures:

1. Check on your microbial samples, graph data collected, and draw below what you see.

2. Analyze your results thus far. Is there a noticeable trend beginning to emerge? If so why or why not?

Day 6 Procedures:

1. Check on your microbial samples, graph data collected, and draw below what you see.

Day 7 Procedures (Last Day):

1. Check your microbial samples one last time, graph data collected, and draw below what you see.

2. Did you notice a consistent trend? Further **analyze and interpret** your data and write down what you have interpreted in the space provided, and update your graph one last time.

3. Walk around as a team to take a look at the results of other lab groups. Note what similarities and differences there are between the different team's results.
4. Answer the associated Post Lab questions.
5. Clean up your lab area and properly discard your petri dish samples.

Post Lab Questions:

1. In your experiment what is independent and dependent variable? Explain why.

2. What were the **results** of your experiment? Were there differences between your experiment and control?

3. Compare your results to other teams that used a different cleaning solution then your group. What differences or lack of difference did you notice? Why do you think this is?

4. Compare your results to other teams that used different fruits and or vegetables. What differences or lack of difference did you notice? Why do you think this is?

5. What is your **conclusion**? What can you say for sure about the solution used and food items chosen?

Extended Response Questions:

1. Analyze the methods used in your experiment. Could your experiment be repeated in space? Why or why not? What improvements can be made if required?

2. Consider the size and interior of the ISS? Think about the resource, limitations, and constraints that currently exist. Why do you believe your group chose the best food items to grow on board the ISS as a food source? If not then why?

3. In your experiment you only tested the edible portion of the plant. Explain how your results would differ if you had been growing the plant from a seed, and needed to test the entire plants. What other plant structures/organs would you also test and why?

4. How does research, similar to yours, conducted by NASA scientist, effect the economy and culture of Florida?

5. *Read the following Scenario*: You and your team mates' project was such a success, NASA selected it to take on board the International Space Station! At first everything is working well, but 2 month into the mission the crew begins to get sick. They test the microbial population growing on the plants and discover the microbial population has tripled in 2 months!
    a. What are some possible reasons for the change in the microbial population? Explain.

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    b. Describe how the human immune system fights off infection? Conduct research to answer this question or use previously learned information.

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