



# NASA Food Technology Commercial Space Center

## You Be The Scientist – Investigating Plant Pathogens in Space by Tyrell Carr

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### BACKGROUND

Many things will be gained from the NASA Program and development of new space food. NASA, in general, will enhance technologies involved in air travel and computer software development. Development of new space food will eventually provide more nutritious items to the public, such as alternative products substituting meat with plant material. In addition, more food products will be developed that will be more convenient, have longer shelf-lives, and do not require special storage. In this exercise, students will be presented with a fictional situation related to space food development on Mars. The take-home message from this exercise focuses on problem solving and critical thinking. Examples presented in this exercise can be used to help solve or make conclusions about common life issues.

The space food challenge involves many fields of study including experimental biology. Experiments conducted in space are used to further understand biological processes in different environments and conditions. In this case, experimental research will be used to grow healthier and diverse agricultural plants in space.

In this exercise, students will take on the role of a visiting scientist working for NASA in the research laboratory located on Mars. The unit that they are assigned to is interested in plant-pathogen interactions in zero gravity and stimulated gravity environments for studies on Earth. This unit is also interested in finding pathogens on Mars since some pathogens can survive extreme environments. Pathogens studied and used in the research laboratory can produce moderate to severe disease symptoms, if released, on some agriculturally important crops such as tomatoes, soybeans, cabbages and potatoes. Precautionary steps have been taken to prevent the outbreak of plant pathogens, such as building the research laboratory and the experimental greenhouse some distance from the food production greenhouse.

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### LESSON SUMMARY

This lesson is designed for advanced high school or college-level students interested in the biological sciences or science in general. Research logic will be presented in a format that will allow students to understand how scientists carry out experiments to detect plant pathogens. Plant pathogen detection in space might be important when plants are grown in greenhouses on Mars or the Moon for food consumption.

Pathogens can be introduced especially if there is a research laboratory present. The availability of plant pathogens and plants in this study are provided from a laboratory stock.

This lesson can be modified to focus on physiological conditions of plants instead of virus infection if plant pathogens are not available. If students are interested in plant-pathogen interactions in terms of disease symptoms, they may want to collaborate with a local agricultural extension office or with a nearby university with a plant pathogen laboratory.

**Time Frame:**

3 hours in a college / university laboratory or  
3 - 1 hour sessions for a high school class

**Overview of Exercise**

Imagine that you are on a colony on Mars, and after a year in operation, both greenhouses (research and food production) and the research laboratory experience problems with water flow. Engineers were dispatched to handle the problem. Since the engineers were not trained in bio-safety procedures, laboratory equipment was moved to gain access to the pipes. General equipment and greenhouse tools were also moved from their designated places and stored in a central location from all three stations. In addition some engineers worked in all three stations experiencing water problem at some point of the repair stage. Two weeks after restoring appropriate water flow; the food production greenhouse technician noticed that several agricultural plants looked abnormal compared to other plants of the same type. The technician noticed that plants were discolored and/or dying. This is a great concern, since other agriculturally important plants could eventually be affected.

The objective is to determine whether the diseased plants taken from the food production greenhouse are infected with a virus. The reason a virus is the culprit of interest, particularly tobacco mosaic virus, is a result of documentation that suggests that it was the only virus used during the current and past month. To make this more interesting, your background is not in plant virology, but in plant bacteriology. The plant virus expert is currently on the Moon supervising a new research laboratory and is unable to communicate with you as a result of technical problems.

Prior to your morning arrival, a research technician has already isolated the protein from both the diseased and healthy plants. The technician has already setup other important equipment and items that might be helpful in this exercise. In addition, reference material has been provided by the technician. These articles can be used to assist in the identification of the pathogen based on plant symptoms. Yet another challenge to your assignment is that appearances can be deceiving. It is assumed that the culprit is a virus, but physiological conditions can also be a factor. It was noted that the automatic water sprinkles / fertilizer system located toward the back of the food production greenhouse tends to lose pressure at irregular intervals after the major water flow repair.

## **Conversation #1 – Pathogens and Detection Methods**

The research laboratory contains plant pathogens including bacteria, fungi, viruses, and nematodes. Some pathogens, like viruses, are stable outside of a plant host. They can be easily transmitted and introduced into plants through small wounds. Many techniques are available to test if a plant is infected with a pathogen. A common and easy practice to determine if a pathogen is present is to extract plant sap and streak the sap on solid medium containing nutrients. This method works for bacteria and fungal infected samples. To determine the presence of a virus or nematode, different techniques are required such as microscopy and biochemical approaches.

The characteristics of plant pathogen types vary from one another. In general, bacteria, fungi and nematodes are living organism compared to viruses that depend on a host to reproduce (replicate).

## **Conversation #2 – Pathogens in Space Verses Pathogens on Earth**

Certain pathogens produce severe symptoms in agricultural crops. When crops are infected on Earth, they can easy be discarded and new crops are then planted. There may be multiple sites that grow these crops, and therefore, the supply is not totally depleted. In space, protections against pathogen infection of crops are important since multiple sites are not available for growing excess crops.

## **Conversation #3 – Isolation of the Food Production Greenhouse**

The best method to protect the food production source is to keep this facility isolated or away from any experimental research facilities. This is the same practice that is done on Earth. Most hazardous and biologically harmful items are kept in isolated and restricted areas. Transgenic plants are also kept in isolated areas away from normal plants.

## **Conversation #4 – Plant Observations**

Observations are generally made by comparing two or more samples of interest to determine any differences. In this case, plants are of interest. The correct method is to use a healthy plant as the reference point against the plant(s) in question. The actual cause of disease or an unhealthy symptom of a plant can be hard to identify. Some diseases or symptoms are easy to determine. For example, a lack of water when growing plants will cause the plant to wilt and dry up if not replenished with water. In addition to the plant symptoms, observation of the soil can be made to draw more conclusions.

## **Space Food**

In order to establish a space colony on Mars or the Moon, a means of food production involving plants is a requirement. The space colony will more than likely also have a research laboratory to support ongoing research on

Earth and to further the space colonization. This research could include studies involving plant-pathogen interactions or other factors that could potentially harm food production. If that is the case, it is possible that a plant pathogen could be released and then could infect agricultural plants. It is also possible that scientists will find plant pathogens on Mars. In addition, pathogens introduced into the environment accidentally can mutate and become more deadly. Therefore, this learning exercise presents conditions that might occur in space. Students will utilize different skills to solve problems related to the infection of agricultural plants. Overall, students will be exposed to the knowledge that the production of food in space involves many precautions and different fields of study such as experimental biology.

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**STUDENT  
LEARNING  
OUTCOMES**

**Communication**

Students will engage in conversation within their small groups to solve and brainstorm a solution to their problem. By engaging in conversations, students will learn that science requires communication to solve problems.

**Learning**

Students will use observation skills to hypothesize whether plants are virus infected or were grown in poor physiological conditions. They will use reference material to draw conclusions. Also, they will use observational skills to identify protein patterns found of a prepared gel. To further determine if a pathogen or physiological condition is to blame, students will design an experiment. Through this experiment, students will develop improved or new methods to prevent the spread of pathogens to the food production greenhouse in the future.

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**MATERIALS**

Students will need the following to participate in this lesson:

1. Reference material package that includes pictures of virus infected plants and plants undergoing non-virus but physiological stress
  2. Plants – virus infected, non-virus infected, non-virus stressed plant
  3. A prepared protein gel that is protein isolated from normal health plants and sick-like plants
  4. Protein Isolation Buffer (Tris Buffered Saline) to practice isolation of protein
  5. Practice Gel for loading protein
  6. Virus Infected Sap for practice inoculating healthy plants with sap
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**INSTRUCTIONS  
GIVEN TO  
STUDENTS**

Students will be assigned to groups and asked to introduce themselves to each other as well as the instructor. Each group will discuss among themselves their personal interests in NASA, space food or space in general. Each group will then share these interests with the rest of the class.

The groups will then fill out the Learning Objective worksheets.

After filling out the first sheet, each group will apply steps 1 and 2 of the scientific method progress to the two or more plants from the research or the food production greenhouse. Students might need to read the Overview of the Exercise again. After defining steps 1 and 2, students will report the findings on paper and to the class.

Responses should include: Appearances (color, height, smell) and what is the causing factor of those appearances.

**Experiment of Interest: Protein Analysis**

**Introduction to Proteins:** Proteins are molecules found in all living organisms (or organisms that once were alive). They are important to carry out biological functions including metabolism, growth, development, or anything pertaining to life. Proteins are also produced by pathogens. Since proteins are produced and unique to various life forms and pathogens, we can use these molecules to support or reject a hypothesis derived from your observations.

NOTE: Students will not be required to perform all aspects of this experiment unless more time is allotted. Some parts of the experiment will be performed prior to class by the instructor. Regardless of this choice, the method of scientific research will be presented in a logical manner.

**Procedure:**

**Individual Assignment:** Using clean and separate plastic pestles and a micro centrifuge tubes containing extraction buffer, grind a piece of a healthy plant and a piece of your hypothesized plant.

Extraction Buffer: a chemical that collects soluble molecules like protein.

After protein extraction, the tube is centrifuged at a high speed to pull down all plant insoluble fractions. The soluble fractions are in the buffer. This step can be admitted.

Once the sample has been cleaned, a protein concentration is needed. By determining the protein concentration, you know the amount of protein that you have isolated.

Already prepared protein samples or mock sample will be supplied.

Individual Assignment: Each student will load a practice gel with a protein or mock protein sample.

Gel: a matrix or mesh of channels that allows fragments of different sizes or charges to be separated.

After samples are loaded into the wells, a current is applied to separate the protein. Remember the protein isolation method we used isolated all the protein from plants.

After running the gel for a certain amount of time, the gel is stained with a dye that binds to the protein. This dye allows the researcher to see the many protein bands separate on the gel.

A gel containing protein will be provided that has already been separated, stained and destained.

Group Assignment: Students will compare the protein patterns from all the hypothesized plant samples to the control plants - tobacco mosaic virus infected plants and physiological stressed plants. Students will see if their hypothesis is accepted or rejected.

Recall the question: Can one test provide the answer to a problem?

### **Experiment of Interest: Protein Analysis Part II**

**Observations:** By looking at a total protein gel, one cannot be certain that his or her hypothesis is correct. Additional experiments are needed that can detect specific proteins. This procedure is called a protein blot analysis or western analysis. In this case, the method is only good if we are interested in determining whether the problem is caused by a virus infection. But at the same time, we can essentially rule out other possible factors especially if the results show there is no virus of interest in the plants.

This is the last experiment for this exercise. The instructor will provide a scan of a protein blot all plants used in the exercise. The protein blot will confirm which samples are actually infected with tobacco mosaic virus.

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**NOTES FOR  
FACILITATOR**

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