

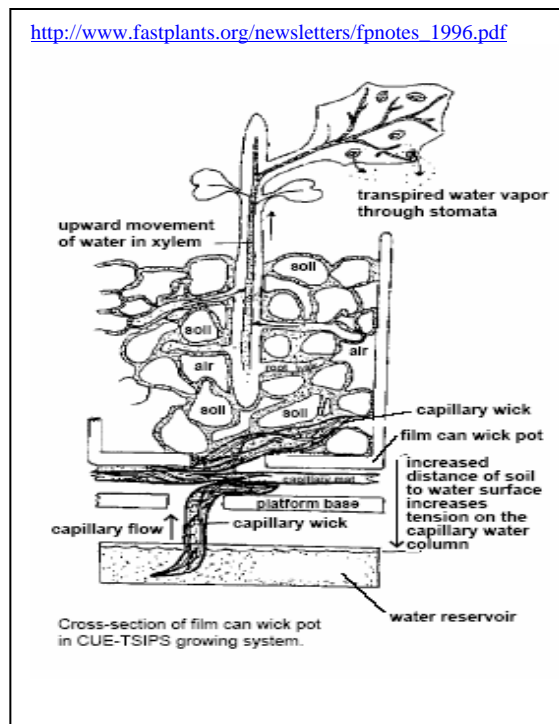


# NASA Food Technology Commercial Space Center

Plant disease in space by Aurelie Rakotondrafara

**BACKGROUND** Plant production is an important component in the development of a self-sustainable, bioregenerative life support system in space. Research is ongoing at NASA to integrate hydroponic, soil-free growing systems into the space program and use it onboard space vehicles as a source of food for extended time periods of exploration in space.

The concept of hydroponic growing systems has been around for thousands of years (i.e. [The Hanging Gardens of Babylon](#), the floating gardens of Aztecs of Mexico). It is based on growing plants in nutrient solutions without the use of soil, but with the use of porous materials, such as sand, for plant support.



Hydroponic systems present several advantages of interest to NASA as compared with the traditional soil-based system: they allow crop production where no suitable soil exists, there is higher productivity in minimal space, there is less weight compared to soil, and they eliminate problems related to soil such as soil-borne pathogens.

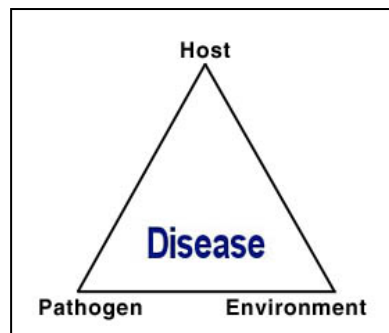
Several environmental factors such as nutrient intake, light, and temperature are known to influence plant growth. Plants grown in spaceflight conditions will be subject to additional environmental stresses such as microgravity and the lack of oxygen that seems to alter the overall plant physiology and development, and

could consequently weaken the plant and increase its susceptibility to opportunistic microorganisms and pathogens in favorable environmental conditions. [Recent studies](#) show that plants grown in space conditions could be infected by pathogens that normally do not cause any disease. In a non-sterile and confined environment such as a greenhouse or space station, microbe contamination can be a significant problem. One of the issues in hydroponic practice is if a plant pathogen contaminates the nutrient solution, the pathogen has the potential to grow, considering the nutritious environment, and spread throughout the system and contaminate all plants since the solution is recycled throughout the closed-system. This will be a serious threat to the agricultural system and consequently for the survival of astronauts during a long duration mission.

This is an introductory lesson about the important concept of [Disease Triangle](#) in plant pathology and how it is applied to plants in space.

The Disease Triangle explains that disease development depends on three factors:

1. The presence of a disease-causing pathogen
2. A susceptible host
3. Favorable environmental conditions for disease development



In the absence of any of the above factors, disease would not occur.

The main goal of this lesson is to help students understand the conditions of spaceflight that can affect plant development and its susceptibility to disease.

The specific aim of this lesson is to develop an experimental system using a crop of interest and a pathogen known to cause disease. Students will address whether the plant is more susceptible to the pathogen when grown in a nutrient solution compared to growth in soil under similar environmental conditions.

Several [root pathogens](#) including bacteria, fungus, and nematodes are known to cause great damage to crop production resulting in poor plant growth, stunting of the plant, or even failure to germinate. Disease development could be measured by disease symptoms (i.e. soft rot, black rot, or rapid collapse of the plant), colonization of root tissue by pathogen, and root length. It is of great interest to study the pathogens' ability to infect a solution.

[The Wisconsin Fast Plant materials](#) are great tools for teaching plant growth and

development. Members of the cabbage and mustard family are fast-growing plants that require water, nutrients, and 24 hour exposure to white fluorescent light in order to grow. Within 4-5 weeks, the [entire life cycle](#) (from planting to flowering and seed harvest) is completed. Such a system could be used to study plant response to disease pathogens in a very short period of time. In addition, cabbage is among the crops proposed for production on the moon or Mars.

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**LESSON  
SUMMARY**

**Audience / Time**

This activity is designed for college level students with a background in biology, plant health protection, and plant physiology. It is an introductory lesson about plant pathology and disease management that could be applied to plants grown in space. The lesson will involve a laboratory exercise.

The lesson will require two 1-hour sessions over the course of two weeks.

The main goal of the lesson is to evaluate the differences in the occurrence of disease when plants are grown in a hydroponic system compared to soil.

**Space Food**

Students will:

- Identify the various factors that could influence disease development in space
  - Identify the possible sources of microbe contamination in a confined environment
  - Compare the effect of pathogens on plants grown in a hydroponic system versus in soil
  - Identify the different stages of plant development by observing plant growth
  - Compare and analyze plant growth and disease development in plants grown in nutrient solution versus in soil
  - Recognize and record disease symptoms by comparing inoculated plants to healthy plants
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**STUDENT  
LEARNING  
OUTCOMES**

**Communication**

The student will:

- Work with teammates to complete the laboratory experiment
- Turn to their partners to analyze their experimental results and formulate conclusions

Write a short research report

**Learning**

The student will:

- Plan an experiment with a design that includes a hypothesis, tests of the hypothesis, and a conclusion
  - Analyze a complex problem and defend reasonable solutions
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**ASSESSMENT/  
EVALUATION**

The student will:

- Identify the various factors (parts of the disease triangle) that would influence disease development in space conditions
- Think about environmental conditions in space, pathogen characteristics: motility, exponential growth, plant susceptibility
- Submit a research report with the hypothesis, the material and methods used to test the hypothesis, the results, the conclusions, and a discussion of the experiment and their learning
- Discuss the case study and offer solutions

**Case Study**

Due to the long duration of your mission in space, you have decided with your crewmembers of the space shuttle XXYD to bring additional seeds of your favorite X crop to be grown in space. Two weeks after launch, you have discovered that the seeds were covered with mold and you have identified the pathogen has fungal Y that produces mobile zoospores and has a large range of host plants (including all vegetables that are currently grown in your growth chamber: that is a serious threat for your survival). In addition to the loss of the seeds, a pipe leak in the storage room caused the spores to spread, contaminate one of the growth chambers where the vegetable crops are grown, and start an outbreak of disease on your crops. However, the outbreak was detected early enough that it did not spread to the second growth chamber. Remember the pathogen is mobile and you have a closed re-circulating hydroponic system (ie, the growth chambers share the same nutrient solution).

As plant pathologists, consider the following questions:

- What measures (cultural practice, sanitation, disease management) should your group take to prevent disease in the second growth chamber?
- What measures should your group take to eliminate disease in the first growth chamber?
- What could have caused the seeds to mold? What measures should your group take to prevent another occurrence of disease in your mother-ship?
- Are those chosen practices applicable for a viral disease outbreak? Or for a bacterial disease outbreak? Why?

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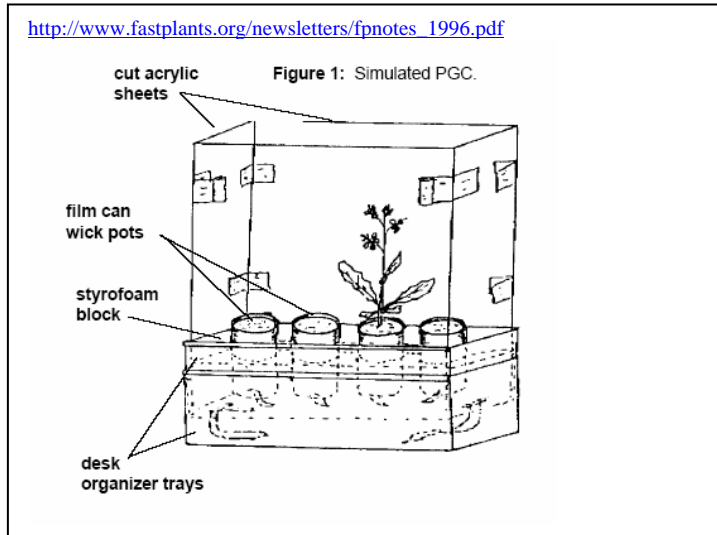
**MATERIALS**

Students will be grouped as pairs (or in groups if space and supplies are limited).

Each group of students will need:

- An [hydroponic system](#) (several methods could be used depending on material available): one for control plant (healthy) and the second for test plants (inoculated with pathogens)
- 2 pots with soil
- Wisconsin Fast Plant seedlings or any other crop seedlings available to the instructor
- Pure isolate of any available bacterial-fungal root pathogens known to cause disease in the selected plant
- Test tubes to prepare the inoculum

- White fluorescent light bulb
- Nutrient solution (1/4 of [Hoagland's solution](#))



**INSTRUCTIONS  
GIVEN TO  
STUDENTS**

The students will be asked to group in pairs or teams of 3-4.

Set up a hydroponic system: one for the control plants, the other for the test plants.

Use 2 plant seedlings per experiment:

- healthy plants grown in soil
- test plants grown in soil
- healthy plants grown in solution
- test plants grown in solution

Prepare pathogen inoculum: Scoop, using a flame-sterilized loop, some bacterial or fungal inoculum (bacterial colonies or fungal zoospore) grown on a petri dish and dilute it into sterile water in a test tube.

Divide the prepared inoculum into two: one half will be used to inoculate plants grown on soil, the other half will inoculate plants grown on the nutrient solution.

Inoculate the plants with the pathogen and place the plants under the fluorescent light.

Record disease development over a 2-week period and write a research report after collecting the data.

**NOTES FOR  
FACILITATOR**

If there is a time limit, the hydroponic system could be pre-set before class.

Leach et al. (2001). Plants, plant pathogens and microorganisms-a deadly trio. *Gravitational and Space Biology Bulletin*. 14(2): 15-23

<http://asgsb.indstate.edu/bulletins/v14n2/vol14n2p20-28.pdf>

<http://quest.arc.nasa.gov/smores/teachers/act3.html>

[http://quest.arc.nasa.gov/space/challenge/learning/farming/Farming\\_In\\_Space.pdf](http://quest.arc.nasa.gov/space/challenge/learning/farming/Farming_In_Space.pdf)

Wisconsin Fast Plants Program:

[http://www.fastplants.org/program\\_description.html](http://www.fastplants.org/program_description.html)

[http://www.fastplants.org/newsletters/fpnotes\\_1996.pdf](http://www.fastplants.org/newsletters/fpnotes_1996.pdf)

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