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PHYCOMYCES IN SPACE:
A Problem in Bioengineering

by

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ABSTRACT

Sustaining life with total automation is a difficult problem for GAS canisters. The length of time between setting the experiment and flight, the conditions of a completely sealed container, no guarantee on launch delay, orientation and the possibility of contamination all tend to exclude experiments with living matter. This experiment examines the growth of a nontoxic, everyday fungus, Phycomyces, in a microgravity environment. Data from this experiment will help define the mechanism by which plants determine the direction of gravity.

The bioengineering problems were solved only after numerous tests and design changes. Phycomyces normally have a shelf life of approximately one week. Storing the fungus for two months, activating the fungus for growth and precise timing were the major obstacles. Solutions were found for storage by drying the fungus spores onto pieces of filter paper. Activation occurs when this filter paper is dropped onto the growth medium, via a solenoid system. The problem of timing is partially solved by growing more than one chamber of the fungus at different time intervals. This experiment proves that the simpler a design is, the better it works.

INTRODUCTION

When placing living matter into a microgravity environment many problems concerning the living requirements of the organism must be solved. In GAS experiments the problems are even greater due to the unmanned conditions of the GAS canisters. Everything must be automated. The G-285 experiment with the fungus Phycomyces encountered

many bioengineering problems due mainly to time factors. The short life span of the fungus, one week, and the delay between setting the experiment and flight was the greatest complication. This experiment is also unique since it runs through launch. NASA has strict requirements for this time period. The possibility of a launch delay required extra attention. The Phycomyces experiment is in a GAS canister with two other experiments and allotted space and weight are little.

PROBLEMS AND SOLUTIONS

The first step in this experiment, as in any experiment, was to determine exactly what needed to be accomplished. The fungus is to grow to the desired stage of life, by launch, in the upright position. At launch the Phycomyces will be placed in a horizontal position and stressed by the force of launch. Once in the microgravity atmosphere pictures will be taken to determine the new direction of growth. Normally when Phycomyces are placed in a horizontal position they bend to grow against the force of gravity (See Figure 1). The outcome of this experiment may help determine the gravireceptor (gravity determining) mechanism of the fungus.

The conditions required by the fungus for growth are not complex. They need the growth medium containing its basic nutrients and air. The only obstacle here is keeping the growth medium moist for the approximate time of two months. To solve this growth chambers will be built completely sealed with added moisture inside. The growth medium will be placed in the bottom of the chamber. This sealed growth

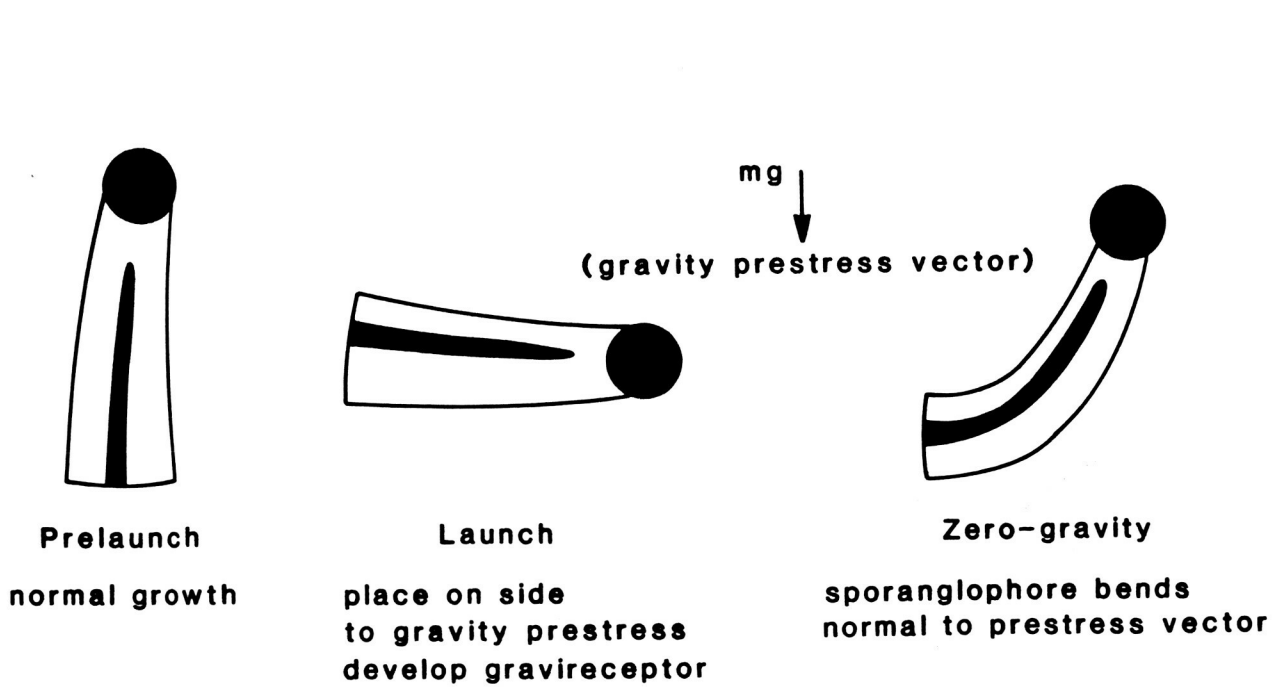

Figure 1.

chamber also solves the problem of possible contamination of this or the other experiments. The growth chamber is approximately one inch by three and one-half inches and will be made out of polycarbonate plastic.

To get the fungus to grow after two months dormancy posed the biggest bioengineering problem. The growth initiation system also underwent the most changes in design. The fungus grows from spores. The first idea was to freeze dry the spores to keep them dormant and heat shock them to restart growth. This design required too much energy. Another idea was using the spore stock solution but this was too hard to keep for two months. Many other ideas were proposed that that required refrigeration. This simply took too much energy. The final idea is much easier. The spores will be dried onto small pieces of filter paper and the pieces of paper will drop onto the growth medium. This system is simpler than anyone imagined it could be.

The next problem encountered was how to drop the pieces of filter paper holding the dried spores onto the growth medium. The spores begin growth when they recieve the needed nutrients from the growth medium. To be in the proper stage of life at launch they must begin growing three days before launch. Therefore they must drop onto the growth medium three days prior to launch. It was suggested to use solenoids to push the filter paper onto the growth medium. Various methods were proposed to do this. One version was to push the filter paper in from the side. The hole through which the paper would fall would be covered with wax paper or similar material to keep the growth chambers environment intact. The solenoid would break the wax paper when pushing the filter paper out. The problem with this method was space. There was not enough room for the solenoids on the sides of the growth chamber. Another idea was to use a solenoid to push on an eye dropper bulb causing a blast of air to push out the filter paper. This method did not produce enough pressure to accomplish the job. The idea of using solenoids was dropped for a while and other methods were considered. One proposed was to have the filter paper resting on a strip of aluminum above the growth medium. A motor would pull out the aluminum strip. The filter paper would fall when the aluminum strip was pulled out of the growth chamber. The motor, though, took too much energy and space.

The answer to the growth initiation problem was in solenoids after all. Solenoids were found that were small enough to fit on the bottom of the growth chamber. A tube will come through the growth medium covered on the top with wax paper. The solenoid pin will be tapered and fit inside the tube with the filter paper on top. The solenoid pushes through the wax paper, pushing out the filter paper letting it fall around the outside of the tube.

Orientation of the Phycomyces is another bioengineering problem. The design for putting the Phycomyces into their proper orientation is also simple. Ideas for motors to turn the growth chamber weren't reasonable because of the energy restrictions. A gimbal system was designed that runs only by the forces of gravity and launch and by

springs. The growth chamber will be attached to the front of the gimbal system. The gimbal allows the growth chamber to turn freely until launch keeping the fungus verticle to the force of gravity. At launch the force turns the gimbal 90 degrees to put the growth chamber in a horizontal position. The gimbal locks into place at this time with a spring mechanism. The gimbal system will be built out of aluminum.

The possibility of a launch delay is a large problem that cannot be fully corrected. The short lifetime of the fungus requires delicate timing. A timer will be set when the GAS canister is closed for the proposed launch date. The timer will pulse the solenoids to begin the growth of the fungus. As a precaution there will be four separate growth chambers attached to the gimbal system front. Each chamber will have its' own solenoid below it and these solenoids will be pulsed about one day apart. This separation will account for up to a one week launch delay. After one week there will most likely be no valuable data.

The camera to be used is a Nikon F-3 model. A timer will be set off by a gravity switch at launch and run for fifteen minutes. This timer will start the camera, autowinder and intervalometer after the vibrations of launch have passed. Thirty-six pictures will be taken two or three minutes apart. When the pictures are done so is the experiment.

A micro-micro lens is to be used. The fungus is less than one millimeter in diameter. The distance between the fungus and the lens will be less than ten inches (See Figure 2). The equipment was found by experimenting with various lenses to get clear pictures. The pictures must allow determination of the direction of growth.

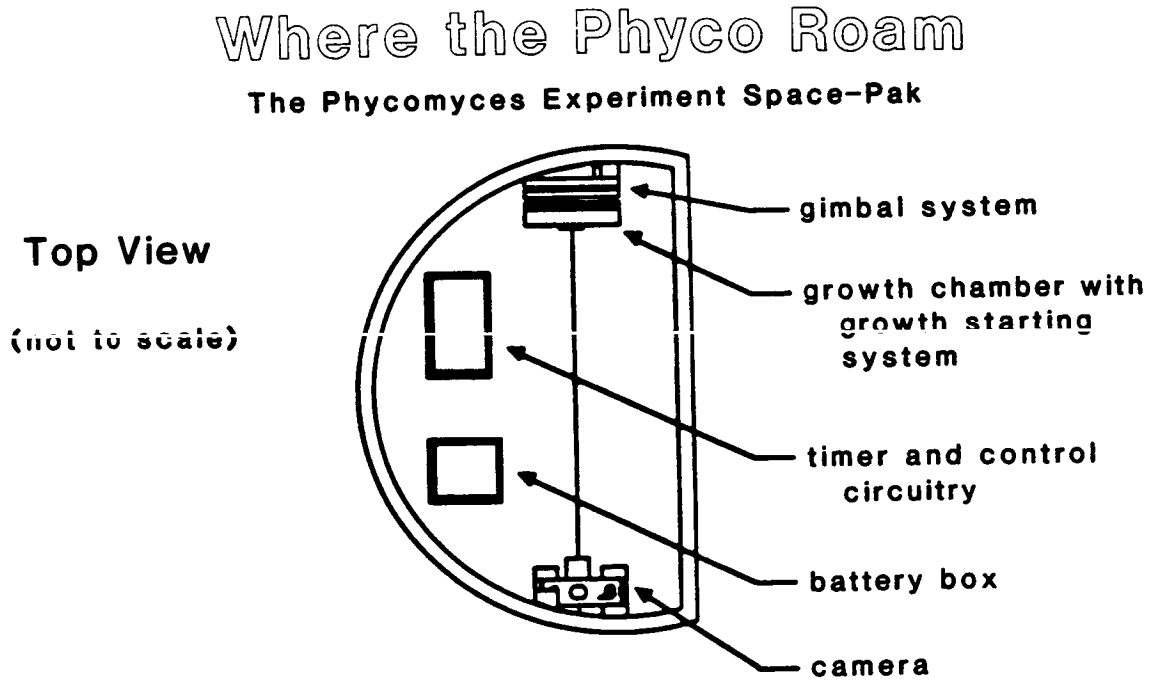

Figure 2.

The lighting creates a bioengineering problem. Light must be used to get the photographs but the reaction of the fungus to the light must be considered. The experiment will be run in complete dark except for when the pictures are being taken. There are no light requirements for the growth of Phycomyces. In fact there can be no light during this particular experiment for accurate data. The fungus will grow towards a light source if one is available. The exception to this rule is red light. Phycomyces is blind to red light. When the pictures are being taken, the intervalometer will also pulse small halogen light bulbs covered with a layer of red and placed on the growth chamber. These light bulbs were chosen for their brightness and for their low energy consumption. Originally a regular camera flash, covered with red, was to be used. This was not used because of NASA requirements. LED lights were considered but did not give off enough light.

CONCLUSION

The requirements or reaction of the fungus had to be considered with all processes and systems proposed. This turned all problems into bioengineering problems. Most of the solutions were simpler than originally thought. The design of all experiments should be kept as simple as possible. As few requirements for growth as Phycomyces has problems with the reaction of the fungus constantly arose. Sustaining life in a completely automated environment is difficult enough and further complications in the design only danger the success of the experiment.