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NASA'S BIOREACTOR: GROWING CELLS IN A SIMULATED MICROGRAVITY ENVIRONMENT

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Introduction

National Science Education Standards (NSES), Science for All Americans, the Secretary's Commission on Achieving Necessary Skills (SCANS) as well as the National Aeronautics and Space Administration (NASA) are all making an effort to promote scientific literacy in America. Unfortunately, major evaluation programs such as the National Assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS) have provided information that suggested our students are not able to compete with peers from comparable countries. Although results indicated that American students are recalling memorized, factual knowledge well enough, the real problem is the ability to *apply* what they know.

Concerned with these reports, the National Science Teacher's Association (NSTA) has developed a mission to support innovation and high quality in science teaching and learning for every student. NSTA recommends less emphasis on factual knowledge (memorization) and information and more *understanding* of the concepts. Science process skills are considered imperative to prepare America's students for the 21st century. The National Aeronautics and Space Administration (NASA) supports this mission and adds that NASA strives to help prepare and encourage the next generation of researchers and explorers.

One method that NASA supports educators and its mission is to publish educational briefs. NASA describes a brief as a publication that ranges from one-to-thirty pages. The focus is on mission discoveries and results. The brief provides curriculum to educators that supports their objectives and NASA's interest. Educational Briefs are specific to the grade level and course so that educators may have choices that fit their methods and students' level. Sometimes, the brief includes lessons and activities teachers may use. For example, NASA's Microgravity Division has designed a student bioreactor. Consequently, an Educational Brief is being written that focuses on how to build a student bioreactor and experiments that can be conducted in it. These experiments mimic the experiments done by NASA and other researchers in the real world of work.

Educational Brief for Student Bioreactor

The Educational Brief is officially titled, *NASA's Bioreactor: Growing Cells in a Simulated Microgravity Environment.* Targeted to secondary students, particularly 10-12, this brief explains why it is important to conduct experiments in microgravity conditions. It focuses on NASA's Cell Science program.

Cells have been cultured for years in petri dishes, producing two-dimensional, monolayered, flat cells. However, when cells grow in the body, they grow three-dimensionally into tissue that structures itself to perform a certain body function. This discrepancy limits research. Therefore, NASA invented the Bioreactor, also called the rotating wall vessel bioreactor. The Bioreactor was developed so experiments could be performed in a weightless environment similar to space. Cells are put in a growth medium and allowed to constantly rotate. This creates free-fall conditions.

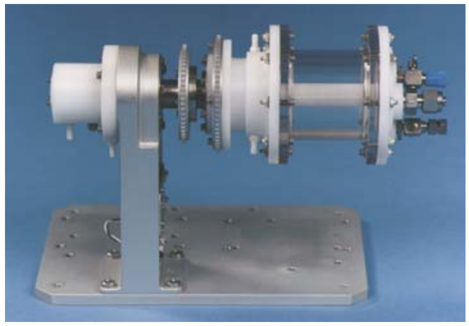

Figure 1: Bioreactor

The Student Bioreactor

The student bioreactor was designed by Dr. Greg Vogt, nationally recognized space educator and author of more than 50 children’s books on space. Using a motor extracted from a toy rock tumbler, and common products that can be purchased at local stores, Dr. Bob Richmond, Mr. Dan Woodard, and Miss Denise Richardson built the bioreactor.

Figure 2: Toy Rock Tumbler

Figure 3: Toy Rock Tumbler Motor

Upon having built the bioreactor, the team proceeded to brainstorm about how to make the rock tumbler easier to build. The motor, shown above, proved to be more difficult than anticipated and many tools were needed to remove it safely. Thus, other motors sources are being considered for trial two of this project.

Despite the difficulty in building the bioreactor, research went forward. The third step, the experiment with Mung beans is described in the brief. The research team allowed the beans to rotate in the student bioreactor for five days. The speed was controlled by a variac. The control group stayed in a vial of water for the same amount of time. Upon the fifth day, the team removed the beans from both groups and weighed them. Also, the length and width were measured. Germination was observed and noted for both groups and data was recorded in a data table. Sample beans from both groups were then planted in potting soil in a plastic cup and placed in the Richardson’s office where ample sunlight could reach the beans.

Seven milliliters of water was added every other day. As of two weeks after planting, the beans were not above the soil. The research is continuing.

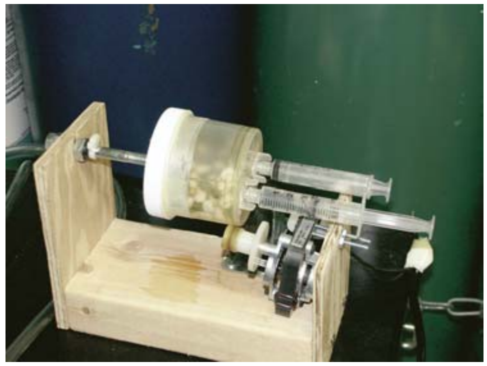

Figure 4: Bioreactor rotates Mung beans.

Results

The beans germinated in the vial of water showed significantly less growth than the beans in the bioreactor.

Future Plans for the Educational Brief

The research team plans to continue revising the Educational Brief until it is no longer in draft form and can be published on the NASA website. Further, the bioreactor is also in trial form and the team will continue to revise until it is as feasibly made as possible. Further activities for students that educators can use are also planned. For example, using the student bioreactor to grow green fluorescent protein and using chemiluminescence as well. This is similar to the experiments in cancer research that involve genes of fireflies and mice.

Resources

The researchers utilized a motor removed from a toy rock tumbler at a local hobby store. The cost was approximately $30. Additionally, two by four wood seven inches long and 1/4" plywood was purchased from a local home improvement store. At that same store, wood screws, a small caster with a fixed base, machine screws with nuts, lock nuts, hex bolts with matching nuts and washers were also purchased. Finally, tee nuts, marine glue, Nalgene plastic jar and Luerlock valves were purchased from an educational company and pharmacy respectfully. The variac used was available in Richmond’s laboratory.

Conclusion

The student bioreactor is a good tool for educators to use to teach science process skills as well as work skills recommended by the SCANS competencies. The National Science Education standards stress inquiry learning and having students *do* science as opposed to just listening to science. The student bioreactor can easily be adapted into the curriculum by educators who wish to follow the various learning cycles.

Acknowledgements

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