SPACE MEDICINE BRANCH REPORT

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Using the NASA space bioreactor for cell culture in microgravity

The following was submitted by Dr. Dave Wolf and Dr. Phil Johnson.

The NASA Space Bioreactor Project is designing and building equipment to demonstrate the feasibility of culturing mammalian commercially useful substances from the culture media. Initial experiments will be directed towards production of valuable biological products such as pharmaceuticals. The incubator is called a "Space Bioreactor." The NASA Space Bioreactor is a completely self-contained life support system for living cells. Eventually, the Space Bioreactor may be coupled to a microgravity continuous flow electrophoresis system (CFES) as one of its applications. The CFES will be used to continuously separate the useful products from the media. The goal is to construct, in a single package, an automatic, usable, self-contained, bioprocessing facility. The individual components of the NASA system are designed to take advantage of microgravity and to be readily scaled up to a larger bioprocessing facility for commercial use.

In microgravity, flow electrophoresis will be used to separate unique and specific cell subsets with desirable growth characteristics and excretory products. These are obtained from cell cultures containing morphologically similar cells which, none-the-less, have different abilities to produce substances of interest. After separation, the chosen cells can be cultured at higher concentrations than possible on earth because the cells remain dispersed allowing efficient transfer of nutrients and gases. Higher densities of growing cells increase the concentration of useful substances in the media. Normal human cells require attachment to suitable surfaces and special culture conditions in order to grow. In the NASA Space Bioreactor, microcarrier beads (175 micron diameter) coated the collagen and suspended in suitable culture media provide the cell attachment sites.

These beads could remain uniformly dispersed in microgravity while, on earth, they would rapidly settle to the bottom of the vessel. The forceful stirring needed to keep them suspended in gravity causes shear forces which damage incubating cells. Stirring at low nondamaging velocities is still necessary in the Shuttle since any orbital corrective movement could cause the beads to move. Additionally, the lack of heat convection on orbit requires some mixing to prevent local temperature changes. The Space Bioreactor is being designed to remove the exhausted culture media and to reintroduce replenished media into the vessel. Precise control of temperature, pH, oxygen and carbon dioxide concentrations, flow rates, valves, and other process variables is achieved by a NASA-invented microprocessor-based control system.

Human embryonic kidney (HEK) cells are to be used in the initial tests. These cells produce plasminogen-activating factors useful in dissolving blood clots, which cause diseases such as coronary artery occlusion and pulmonary embolus. Over 30 electrophoretically distinct HEK cell subsets have been identified. High plasminogen-producing cell fractions will be isolated with the CFES and then grown within the Space Bioreactor. Crude products will be purified during a second pass through the CFES. Any useful cellular product is a potential candidate for this type of space bioprocessing.

A microgravity environment offers potential advantages for establishing a commercial bioprocessing facility. In normal gravity, commercial bioreactors producing pharmaceutical products are compromised by sedimentation and inadequate transfer of oxygen. Shear forces generated by the stirring cause severe cellular damage. The NASA Space Bioreactor is being designed to minimize these adverse effects and to allow use of higher cell concentrations. In addition, CFES is able to preselect the cells for culture to optimize the production rate. CFES also produces purer separations in microgravity than on Earth. This occurs because no convection currents are produced. Convection currents are caused by the heat generated during the passage of the electrophoretic currents, leading to an intermixing of the separating fractions.

Early flight experiments have suggested increased growth rates and cell sizes when cells are cultured in microgravity. Initial ground and flight tests will concentrate on optimizing the bioprocessing parameters such as media composition, flow rates, bead and cell concentrations, and gas mixtures. Flight protocols are being developed to exploit the advantages of microgravity to enhance cell culture techniques and to improve recovery of useful products. The first test flight will be during mid-1987.

This project is directed by Dr. Dennis Morrison. Dr. Dave Wolf is the Chief Engineer. Technology Inc. is the contractor. The TI effort is directed by Andy Anderson. For information, contact Dr. Morrison, code SD, Johnson Space Center, Houston, TX 77058.

Genetic engineering book examines the 'delicate balance'

The "delicate balance" between government's responsibility to protect the health and welfare of its people and its responsibility to encourage industry is explored in a new book on biotechnology.

Published by the Academy Industry Program of the National Research Council—sponsored by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine—the book is based on proceedings of a 1985 biotechnology conference.

The book reviews the foundations of biotechnology and its emergence as a major force with more than 200 companies in the United States working on biotechnology research.

"Genetic engineering," the book says, "has done more than give researchers the ability to understand the genetic structure of living things; it has given them the ability to change that structure."

Included in this category is the gene therapy, now near clinical testing, in which genetic disorders are treated by gene splicing.

The book may be obtained for $9.95 prepaid from the National Academy Press, 2101 Constitution Ave., NW, Washington, DC 20418.

Clark, Hawkins, Moore seek FNS President-Elect post

Candidates for 1986–87 President-Elect for the Flight Nurse Section are Lt. Col. Patricia A. Clark, USAF, NC; Capt. Janice E. Hawkins, USAF, NC; and Lt. Col. Terry R. Moore, USAF, NC.

Candidates for the Board for 1986–89 terms are Capt. Steven E. Beals, USAF, NC; Maj. Glennda L. Bruce, USAF, NC; and Maj. Eileen A. Smith, USAF, NC.

Biographies of the candidates will be included when the ballots are mailed.