MUSEUM

Cell culture devices on display at National Museum of Health and Medicine studied effects of weightlessness in space

IN THE EARLY 1960S, the Soviet Vostok and the American Mercury and Gemini space missions proved that man could survive and work in space. As both countries gained confidence and space missions became longer, it was observed that weightlessness profoundly affected the human body, causing cardiovascular changes as well as a loss of bone density. Due to the small number of individuals involved, it was not clear if these changes were due to being in outer space or a result of individual variations. If these changes were a result of weightlessness, did they represent the beginning of a downward trend? Would they level off over time? Or would the changes be cyclic? If longer space missions were to be contemplated, these questions had to be resolved. Three automated cell culture devices in the collections of the National Museum of Health and Medicine document efforts to answer these questions by studying the effects of weightlessness at the cellular level.

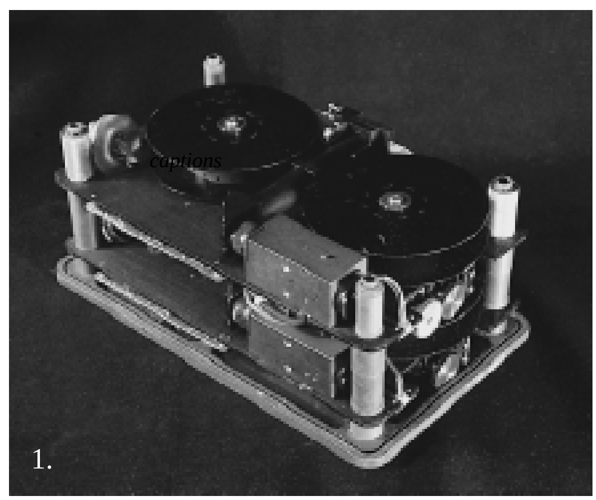
P. O'B. Montgomery, Jr., MD, professor of pathology at the University of Texas, Southwestern Medical School in Dallas, Texas, developed the first automated cell culture laboratory intended to investigate the effects of weightlessness on human cells. He named the device the Woodlawn Wanderer Nine, for several reasons. "It is named 'Woodlawn' for the hospital in which our laboratory is located. It is named 'Wanderer' for the fact that we expect it to wander around in space—and, we hope, come back. It is named 'Nine' not for the fact that this is the 9th time we have tried this, because it is the 199th time that we tried it, " he says.

The first device was intended for an Apollo mission. Smaller than a shoe box, it contains two automated cell culture specimen chambers and two 40X phase-contrast microscopes. The cells were cultured in the chamber, which had a pump that fed them every 24 hours. During the mission, two reels of film were intended to photograph the cells every minute for up to 21 days. The Apollo mission that would have carried this device was canceled after the Apollo 13 accident, and it was never used.

A second Woodlawn Wanderer Nine was used in the Skylab III earth orbital mission in 1973. While it was considerably larger than the first version, it was only the size of a small tabletop radio. It had a 20X microscope and a 40X microscope for each specimen chamber, which could be switched with an external knob. Stock cultures of human fetal lung tissue cells (WI-38) were used in the experiment. The film pack photographed the cells for 28 days. After the mission, analysis of the film revealed no differences in the miotic index, cell cycle, and migration between the cells that were launched into space and the control cells on the ground, suggesting

Cells, *continued on page 9*

1. *Woodlawn Wanderer Nine, Apollo version*
2. *Woodlawn Wanderer Nine, Skylab version*
3. *Space Tissue Loss Module (STL)*



1.

2.

3.

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that weightlessness had no effect on human cells.

However, the results from the Woodlawn Wanderer still begged the question of why a decrease in muscle tissue and bone density was observed in astronauts returning from space. Changes in cell culturing techniques allowed for the cultivation of bone, muscle, and blood cells (cells that appeared to be affected by weightlessness), instead of the fetal lung cells used previously. The development of the space shuttle allowed for a new set of experiments to gain insights on how weightlessness affected the human body.

In 1992, the STL (Space Tissue Loss) Module, developed at the Walter Reed Army Institute of Research by William Weismann, COL, MC, USA, was launched on the Space Shuttle Atlantis (STS-45) to study the bone cell maturation under microgravity conditions. The STL is a self-contained modular cell culture laboratory intended to rigorously control the environment surrounding the mass of cultured cells while in space. The electronics and cell culturing pumps are contained in a plexiglass box protected by an aluminum skin that is approximately the size of a microwave oven. The cells, which for this experiment were bone starter cells (osteoblasts) placed on tiny beads to grow more like bone in the human body, were placed in plastic bags. The cells were automatically fed an oxygenated media to ensure sustained growth during the flight.

The experiments indicated that the metabolism of bone cells changed during the flight and the mineralization of the bone fibers was impaired. Such changes would decrease the strength of the bones. Subsequent experiments with bone cells on the Discovery flights in December 1992 and April 1993 confirmed the results. Bone cells used in the latter flight continued to be cultured on the ground after the flight to determine if the changes due to space flight were reversible.

Unlike the Woodlawn Wanderer Nine series, the STL was not intended to monitor the development of the cells while in space. Instead, it was to provide a stable environment for the culturing of cells that would be studied on the ground after the Space Shuttle landed.

The STL could be configured to culture cells for a number of different experiments during one space mission. In November 1994, Space Shuttle Endeavour included two experiments using cells from chicken embryos—a study by Dr. Adele Boskey of the Hospital for Special Surgery in New York on the effects of space flight on calcification and cellular activity in maturing cartridge cells and another by Dr. Herman Vandenburgh of Miriam Hospital and Brown University on the effects of space flight on muscles.

The STL could also be configured to automatically deliver drugs during the mission. This capability was used in December 1992 for an experiment to study how white blood cells respond to antigens from infectious agents and tumors while in a microgravity environment. Another STL used in January 1996 tested tissue loss pharmaceuticals for efficacy.

The STL can be custom-configured for each flight based on the needs of the experiment. The analytical configuration STL-A allowed for the experimentation on tissue at the micromolecular level. An STL-A used on the mission in January 1996 included experiments to study biochemical and functional loss of muscle, bone, and endothelial cells due to micro gravity stress and to evaluate cytoskeleton, metabolism, membrane integrity and protease activity in target cells. The STL-B was configured to study macromorphological alterations of tissue. In July 1995, an STL-B was used on the shuttle Discovery to study the development of the medaka fish egg in a microgravity environment. The STL on this mission was configured to record the changes of the eggs using an onboard videomicroscope.

The STL has shown that weightlessness alters metabolism, immune cell function, cell division, and cell attachment. In addition to providing information about how life adapts to the weightlessness of space, it is also increasing knowledge about basic cellular function. The technology that allows for the culture of cells in space has advanced since the Skylab mission. While the results of the early research did not observe changes in cellular activity, the Woodlawn Wanderer Nine demonstrated that this research was feasible. However, advances in cell culture techniques and improvements in electronics allowed for the development of the STL, which was able to study the cells most affected by weightlessness and produce more relevant results. At the Fifth International Congress on Cell Biology in Madrid, Spain, in July 1992, Dr. Thora Halstead, manager of NASA's Space Biology Program observed, "The successful operation of the STL Module signified a landmark technological achievement in our ability to study cell functions during space flight."

Special thanks to Cpt. William B. Ross, USN, MC, chair, Department of Scientific Laboratories, AFIP; Tom Cannon, project manager, STL, Department of Space Biosciences, Walter Reed Army Institute of Research; and Maj. Loraine Anderson, USAF, MC, for making these acquisitions possible.

Professional Services, *continued from page 1*

needs, including neuropathology, ophthalmic, hematologic and lymphatic, cellular, and scientific laboratories; **Group IV.** Departments with unique programs and space requirements, including environmental, veterinary, infectious diseases, and radiologic pathology; and **Group V.** Departments that offer medicolegal and forensic expertise—the Office of the Armed Forces Medical Examiner and Department of Legal Medicine. Rounding out the Directorate of Professional Services will be **Group VI.** Specialized Services (formerly Ancillary Services). "Handling the day-to-day functions in Specialized Services (education, research and epidemiology, telemedicine, medical and molecular genetics, credentialing, and accessions/repository) will be six experienced administrators," Mullick notes, "and together with the strong administrative support in CAP, this new structure will help us continue our outstanding scientific work into the 21st century."