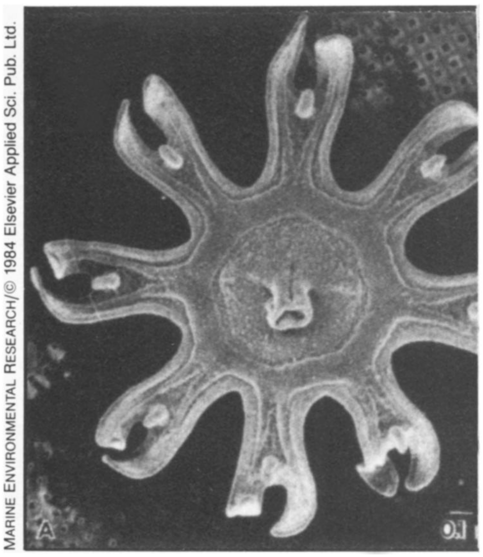
Biomedicine Blasts to New Heights

Shuttle experiments probe basic physiology

By KATHRYN HOPPE



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Jellyfish polyp (above) becomes an ephyra (facing page) after six days of metamorphosis. The ephyra will mature into the more familiar adult form.

Some fundamental questions about life on Earth may best be answered in space, as NASA researchers continue to expand our medical knowledge with a broad range of life sciences experiments shuttled into orbit.

The most recent biomedical mission, Spacelab J, launched 20 studies into space for eight days last month. Astronauts kept busy conducting experiments on themselves and caring for a menagerie that included two carp, four pregnant frogs, 30 fertilized chicken eggs, 180 hornets, and more than 7,600 fruit flies.

While investigators still need time to analyze the data from this latest venture, results from earlier flights have already raised new questions, prompting scientists to reexamine some traditional theories about how the human body functions, says Ronald J. White of NASA's life sciences division in Washington, D.C.

NASA's first Spacelab Life Sciences mission (SLS-1) carried 18 investigations into orbit for a nine-day flight in June 1991. After more than a year of analysis, researchers gathered this August at the World Space Congress in Washington, D.C., to discuss their results.

Unlike previous biomedical studies, SLS-1 was designed so that scientists could monitor and compare the long-term health of their astronaut subjects for several months before and after, as well as during, the actual flight. These studies revealed new details about the physiological changes that occur as the human body adapts to different gravitational environments (SN: 8/1/92, p.70).

Other investigations focused on the 29 white rats flown aboard the SLS-1 mission. Many of these experiments probed adaptations of the so-called antigravity muscles, which support the body and maintain posture in Earth's gravity.

One of the most unexpected results revealed that muscle cells in space do not process energy in the same way they do on the ground, White says.

In Earth's gravity, muscle cells use both fatty acids and carbohydrates for fuel, explains Kenneth M. Baldwin, a physiologist at the University of California, Irvine. Using biochemical tests, Baldwin and his co-workers determined that, in space, muscles appear to lose their ability to process fatty acids and thus rely more on carbohydrates for fuel.

This change in energy processing came as a "big surprise" to the researchers, says Baldwin, who adds that the study provided only a few hints as to the causes of the switch. He believes further studies may reveal details that could lead to alterations in astronauts' diets.

Related investigations provided new details about previously studied effects such as muscle atrophy—the loss of mass and strength that occurs when muscles remain inactive. In the past, astronauts have lost muscle mass in response to the absence of gravitational stress in space, but such changes remain difficult to measure in humans.

The rat's higher metabolic rate causes these effects to occur faster, making short-term changes easier to study. During the nine days of SLS-1, Baldwin and his co-workers found that the rats lost as much as 25 percent of the mass in their antigravity muscles. Muscles used primarily for locomotion atrophied less. After returning to Earth, the rats regained muscle mass slowly: It took twice as long to regain mass as to lose it.

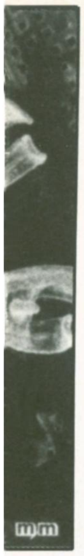
These and related studies highlight the need to counteract the effects of space travel so that astronauts can readapt more easily to life on the ground. Baldwin believes future astronauts may prevent atrophy by adding new exercises to their daily routine. Astronauts should "do the equivalent of pumping iron" while in space, he says.

Baldwin plans future studies to investigate the relationship between lost muscle mass and the loss of muscle function in space, as well as the biochemical signals that control atrophy.

NASA

Astronaut Mae C. Jemison floats in the science module of Spacelab J aboard the orbiting shuttle Endeavour.

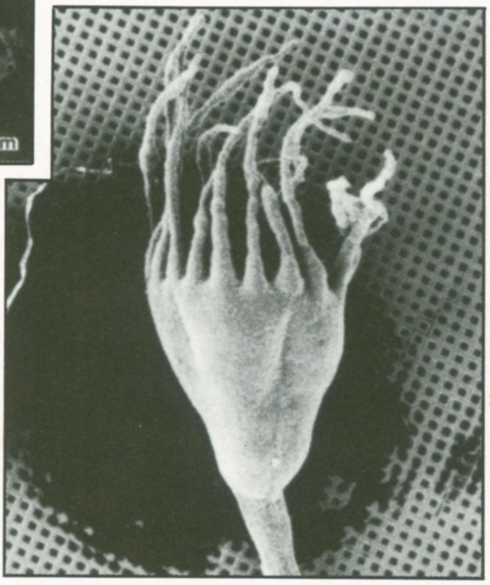
The human and rat passengers aboard SLS-1 also kept company with more than 2,400 jellyfish polyps. These primitive animals prove ideal for space-based experiments because of their small size and quick development, says Dorothy B. Spangenberg, a developmental biologist with Eastern Virginia Medical School in Norfolk. During metamorphosis, jellyfish undergo cellular processes similar to those seen in more complex animals and thus may reveal details about the effects of microgravity on organic development, Span-



genberg says.

In the early stages of their life cycle, jellyfish exist as stationary polyps less than 3 millimeters long. Under the proper conditions, these polyps metamorphose into a free-swimming stage, known as ephyrae, in just six days.

After SLS-1 returned to Earth, Spangenberg and her co-workers examined the jellyfish ephyrae that had developed in space. While most of these animals appeared normal, the group as a whole displayed a significantly higher rate of locomotor abnormalities – such as trouble coordinating their muscular pulsing movements – compared with a control group of ephyrae raised entirely on Earth. Roughly 18 percent of the space-developed ephyrae showed such effects, as opposed to less than 3 percent of the Earth-developed controls.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This suggests that microgravity interferes with the development of the neuromuscular system, the nervous system, or the gravity receptors in certain jellyfish, says Spangenberg, who plans further space-based studies to investigate the causes of these effects. She notes, however, that the normal metamorphosis observed in the majority of the experimental jellyfish indicates that cellular development does not depend on gravity.

Jellyfish will again blast into space in 1994 for a series of experiments designed to investigate their exact tolerance for different levels of gravity, Spangenberg says.

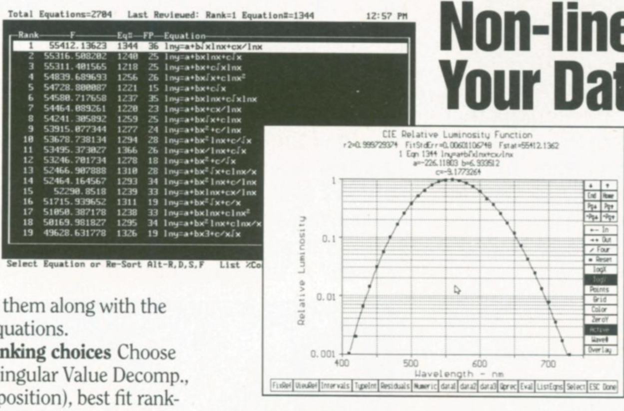
While planning for future missions, scientists await the first results of Spacelab J, which should be announced toward the end of this year. All of the experiments aboard yielded data, says Mission Manager Aubry King of NASA's Marshall Space Flight Center in Huntsville, Ala. However, not every investigation proceeded as planned. High humidity plagued an orbiting horde of hornets, which did not construct the combs scientists had planned to examine for structural differences.

The high-flying frogs produced more solid results, laying hundreds of eggs that astronauts artificially fertilized in space. Hundreds of tadpoles from these eggs, along with embryos from the 30 chicken eggs flown on the mission, should provide investigators with information on vertebrate development and bone formation in microgravitational conditions.

Scientists will examine the effects of another environmental change experienced during space travel – higher levels of radiation – by searching for mutations among the mission's fruit flies. Human astronauts and fish studied in other Spacelab J experiments will provide additional clues to physiological adaptations to space.

As researchers analyze the data from these past experiments, they look forward to new studies planned for the future. NASA's schedule for the next few years includes three shuttle missions that will carry biomedical experiments, including a second Spacelab Life Sciences (SLS-2).

Such investigations are "only the first in a series of shuttle missions dedicated to life sciences," says White, who predicts that space-based experiments will continue to produce significant results. □



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