To fill the gaps in space medicine

Watched over as no astronaut ever was, a monkey will become the first creature to spend a solid month in space

NASA

Biosatellite candidate takes a drink from his test couch.

The first five living earth creatures to orbit the planet were dogs. The early days of space research were lavishly populated with microorganisms, mice, rats, insects and other animals, as scientists attempted to make sure that the strange environment of the new frontier would be safe for man.

Since then, Mercury, Gemini and Apollo astronauts and Soviet cosmonauts have found space quite livable, if not exactly homey. For the scientists, however, this is not enough. Only limited biomedical monitoring and experimentation has been possible with human space travelers, compared with the detailed kinds of studies necessary to fundamental understanding of the effects of space travel.

Now that man has spent thousands of hours orbiting the earth and even been twice to the moon, such a detailed study is set to begin on June 22. The subject: a pigtail macaque monkey, elaborately wired and instrumented to let researchers on earth keep track of everything from the density of his bones to the movements of his eyes. The monkey will be carried into orbit in Biosatellite D, to spend an entire month exposed to the weightlessness and radiations of space.

This will more than double the manned record for time in space, set when Gemini 7 stayed aloft for two weeks in 1965. More significant, however is the amount of information that stands to be gained from the mission. "It will be the most exhaustive study ever made of an organism in weightlessness," says Benny B. Hall, the National Aeronautics and Space Administration's deputy bioscience director, "far more so than could be made with a man."

The only biomedical information monitored on U.S. astronauts is respiration and heart rate, augmented by blood, tissue and waste samples gathered before and after each flight. Experience has shown more elaborate instrumentation to be unnecessary to crew safety; in addition, the equipment would add weight and take up valuable space in the communications bands.

Past flights have revealed losses of bone calcium and of as much as a pint of red blood cells; both levels returned to normal back on earth. The medical researchers, however, are not satisfied. Dr. Charles Berry, NASA chief medical researcher, would like to have additional data such as brain activity, heart sounds which indicate the speed of the heart's response to its signals from the brain, and blood pressure.

The main reason more hasn't been done, however, has been the basic difficulty of adequately instrumenting an astronaut for full medical data without interfering with his comfort and performance. Even a simple inflatable blood-pressure cuff would grow uncomfortable or even painful after a short time in space, and such sophistications as skull electrodes and surgically implanted catheters would multiply the problem intolerably.

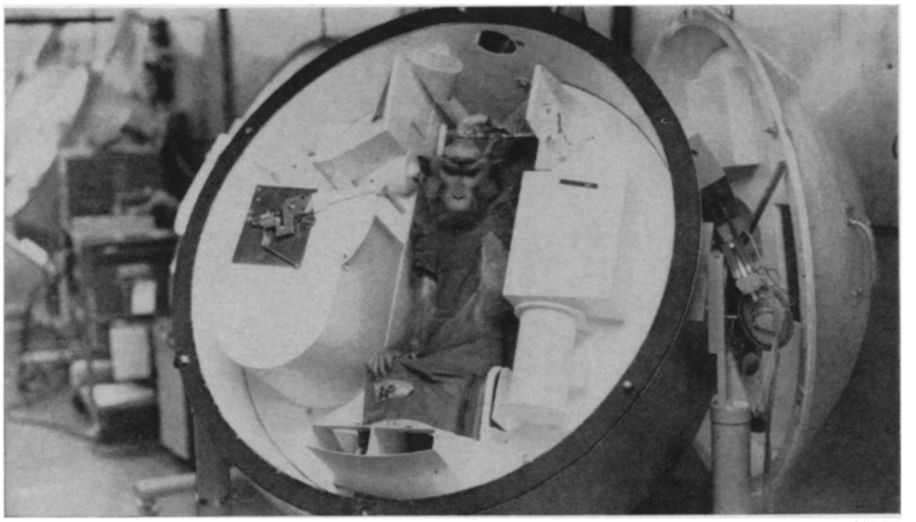
The biosatellite monkey will make such evaluations possible. Restrained in his custom-fitted couch, he will have only limited tasks to perform, such as pushing a food-dispenser button and working two behavioral tests, so elaborate instrumentation will be more tolerable.

Embedded in his brain, and passing out through tiny holes in the skull, will be 11 electrodes, placed to monitor the whole range of brain functions.

Another pair of sensors will monitor eye movements, which, during sleep, can indicate dreaming. Two more in neck and back muscles will report on muscle tension and activity, while others on the chest will provide the same heart rate and respiration data that are monitored on the astronauts.

Four catheters will monitor blood pressure in the principal veins and arteries, while one in the bladder will collect urine continuously for analysis by an automatic device that will look for signs of increased levels of calcium and creatine, indications of deterioration in bone and muscle tissue. It took researchers two years and more than $1.5 million to compress the urine-analyzing functions of several large pieces of equipment and a lab technician into a virtual shoebox that would fit in the cramped satellite.

Making the most of the data radioed to earth will be specially developed computer techniques designed to correlate the voluminous sensor readings into recognizable patterns. As little as five minutes of data per orbit should be enough to determine sleep patterns, says principal investigator Dr. W. Ross Adey of the Brain Research Institute of the University of California at Los Angeles,



NASA

Biosatellite mockup shows its simple, and hopefully monkey-proof, interior.

and data spurts as short as one second are expected to yield useful information on such functions as decision-making.

A great number of before-and-after-flight tests are also planned. The change in the amount of normally radioactive potassium in the monkey's body will be measured as an index of loss of body cells. Other analyses will cover changes in red blood cells, plasma, total body water, extra-cellular and intra-cellular fluid, hemoglobin and plasma protein. More than 30 comparison tests will be made of solid and liquid wastes, including those for steroids, calcium and phosphorus.

Before-and-after X-rays will be taken at 17 different points on the monkey's spine, hands, arms, feet, legs and pelvis. Astronauts are X-rayed only on the hands and feet; the biosatellite monkey will be X-rayed at 4, 7, 14, 30 and 60 days after the mission to evaluate his recovery rate.

In addition, studies will be made to find any changes in spermatozoa or presperm cells, and the monkey's development will be watched for several years to see if his maturation has been affected by his long stay in space.

Exactly which monkey will make the trip has not yet been decided, and will not be until 12 hours before the scheduled launch. At that time, the healthiest, most agreeable and best-trained candidate will be picked from among five, all of whom have been fully instrumented. Then, while the chosen monkey orbits the earth, the other four will fly a simulated version of the same mission in identical spacecraft on the ground.

To insure that the researchers find out as accurately as possible the effects of weightlessness, the biosatellite has been designed to keep the monkey even more weightless than is a human astronaut. In space, an astronaut is approximately weightless, of course, but the movements and deliberate maneuvers of the spacecraft create small accelerations that have the effect of a tiny bit of gravity—perhaps a few hundredths or thousandths of earth's gravity.

An astronaut's own movements cancel out some of the effect of the lack of gravity. But the biosatellite will be held by a stabilization system so that the monkey is subjected to less than 0.00001 g for at least 95 percent of his time aloft, and the monkey's movements will be restricted to keep him from shaking things up. Every foreseeable source of acceleration has been taken into account, all the way down to the miniscule 0.000007-g drag caused by the fringes of earth's atmosphere at the satellite's 220-mile-high orbit.

The planned June 22 launch has already been delayed once by a minor malfunction, from June 18, and although engineers are confident of making the new date, a delay of more than another week or so could bring real trouble. Scheduled for launch from the same pad on July 23 is the sixth Orbiting Solar Observatory, with the Pioneer E satellite to follow on Aug. 14. Both of these spacecraft will require a few weeks of set-up and check-out time on the pad, so the biosatellite will have to go or be dismantled by late June. This is a double problem since the monkeys are being very carefully selected for body weight, age and development. Also, a postponement of two days would put the spacecraft's recovery—by mid-air snatch of its parachute lines if possible; otherwise by ship pickup—on the same day as Apollo 11's return.

Originally, there were to have been two identical 30-day primate flights, until President Nixon's budget request eliminated the second one, scheduled for 1970. The House space committee is trying to get it reinstated, but NASA sources feel it may be September before the outcome is known. ◇

DATA AT LAST

An approach to mine safety

The death flutterings of caged canaries were once the only warning coal miners had of impending suffocation in their black tunnels. Often the warning came too late for escape.

That was in the early 1800's. A coal miner's lot had all the characteristics of a Dickensian horror story and the daily threat of death was considered part of the business. No one kept records of the number of miners who never came home from work.

Then at least a few persons began paying lip service to safety. Others archived the death rate. In the century from 1869-1969, violent death has claimed 120,000 miners in the U.S.—an average of 100 a month. With appalling regularity and little notice, men die in cave-ins or from equipment accidents. Occasionally they die when methane gas explodes, trapping and killing whole work crews. Such an explosion is believed to have been the executioner of 78 workers who died last November in Consol No. 9 (SN: 12/7 p. 567) in Mannington, W. Va. That so-called safe mine was operated by the Consolidation Coal Company, one of the giants of the $3 billion a year industry.

The catastrophe drew national headlines as would-be rescuers stood by helplessly for days, because of continuing methane explosions and fires. United Mine Workers President W. A. Boyle said on the spot, "As long as we mine coal, there is always this inherent danger of explosion." Former assistant secretary of the Department of the Interior, J. Cordell Moore, philosophized, "We don't understand why these things happen, but they do happen." West Virginia's then governor, Hulett C. Smith consoled distraught families by saying "What has occurred here is one of the hazards of being a miner."

After years of hearing but hardly listening to such remarks, officials in Washington finally became cognizant of what was being said. Stewart L. Udall, Interior Secretary under President Johnson, denounced the whole state of mining safety as "unacceptable" and within three weeks called a national conference on mining safety at which even industry officials conceded that more could be done to keep the work force alive.

Disregard of existing safety precautions, indifference to research and a pre-20th century attitude have all contributed to making coal mining the nation's most hazardous industry. Now, at the end of a modest five-year research program, the Bureau of Mines is proposing new and, presumably, more effective approaches to handling the methane threat.