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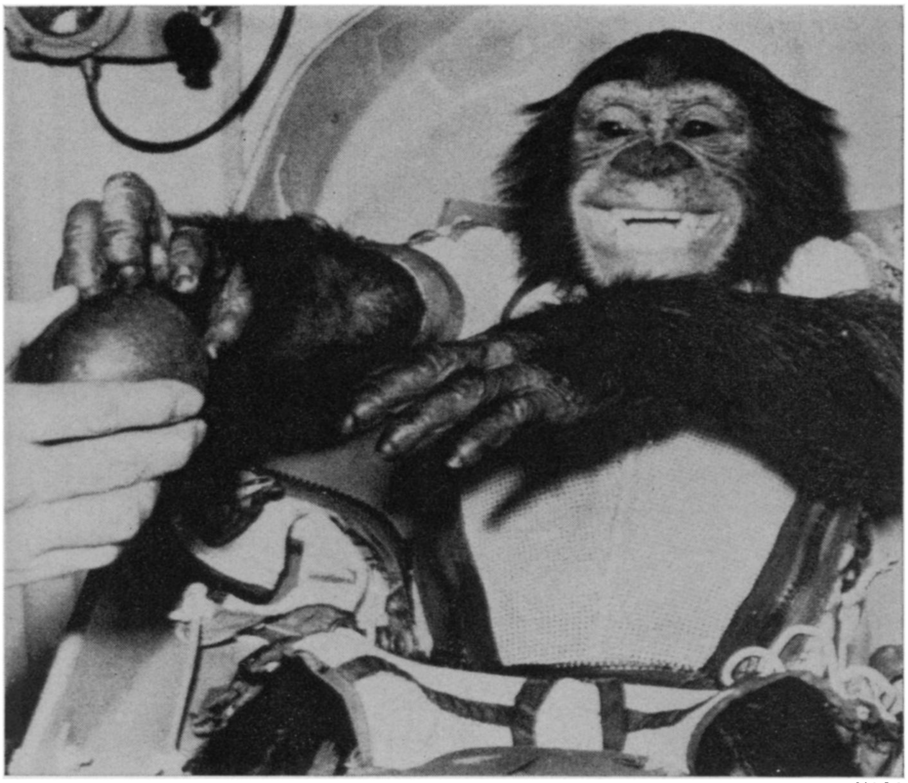
Pigtail macaque and a new order of space sophistication →



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Ham home and hungry: was his trip science—or unworthy of the name?

BIOMEDICINE

Return of the space monkeys

An orbit-bound simian may outdo even human astronauts as space medicine takes on more aspects of a science.

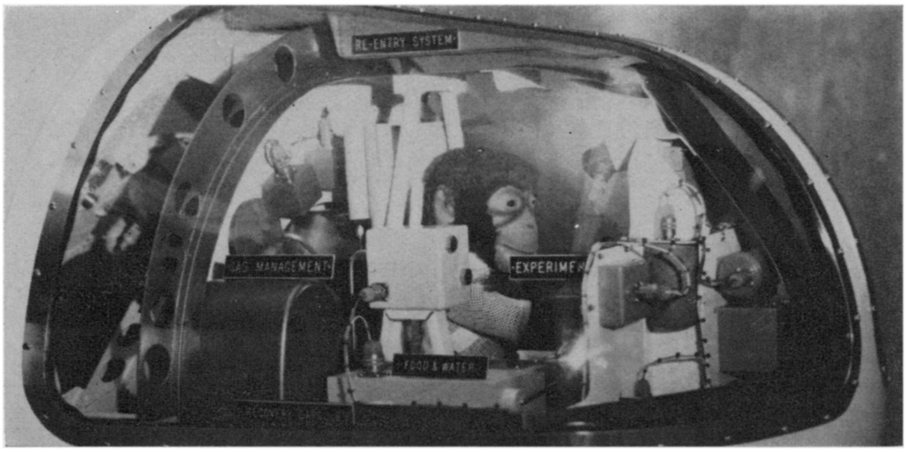
by Jonathan Eberhart

At the Manned Spacecraft Center in Houston, some 55 astronauts are training rigorously for duty in space. At the same time, in California, about 200 pigtail macaque monkeys are engaged in a project aimed at easing man's way in that strange environment.

The climax of the monkeys' efforts should occur late next March, when one of their number is set to be launched on a month-long stay in orbit, instrumented with more than two dozen sensors to report on his brain, heart, eyes, muscles, circulation, coordination and general welfare. The experiment is the first of a pair, each to last 30 days.

Biomedical research, of course, has been a major part of U.S. manned space flights, as well as those with lesser primates and other creatures. But the scientists planning for the upcoming monkey mission believe it will make them all seem pallid, and perhaps even amateurish. "I have nothing but contempt for the sort of medical experiments that went into the Gemini program," says chief investigator Dr. W. Ross Adey of the Brain Research Institute in the Space Biology Laboratory of the University of California at Los Angeles. The experiments and techniques planned for the coming flight, Dr. Adey believes, will be a major leap forward over the previous projects.

As for early efforts such as the flights of Mercury 2 and 5, which carried two



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Toy monkey faces test panel in mockup of Biosatellite 3's crowded cabin.

chimpanzees named Ham and Enos respectively, Dr. Adey finds them almost beneath notice. They "scarcely warranted the name of an experiment," he says. Even the elaborate flight of Biosatellite 2 last year, in which 14 different life forms spent three days in orbit to study the effects of weightlessness and radiation (SN: 3/9, p. 230), "was trival in every way by comparison." For example, he says, it didn't even include telemetry to report on the passengers' progress in flight.

Ham and Enos were selected largely on the basis of body size, arm and leg length, general health and the ability to learn to press the proper lever in response to a colored light. For the Biosatellite monkeys, this is just the beginning. For these missions, the candidates are being selected almost as painstakingly as would be a human astronaut.

"The screening procedures are incredibly complex," says Dr. Adey, "going down to the sedimentation level in his urine, and then he may drop out of the program because he can't learn to suck on a bottle." Urine sediments, in fact, have become a particularly important criterion since last November, when the first full-length ground test of the spacecraft had to be interrupted twice to unclog the spaghetti-thin tubing of the automatic urine transport system. To keep the problem from recurring, the researchers have had to change the recipe of the food pellets planned for the flight and add some vitamin C, as well as redesign the sterilization procedures used while the monkey is being installed in the spacecraft. Other urinary characteristics considered in picking candidates include acidity and calcium content, both of which could affect clogging of the system.

The chosen space monkey will also have to have mastered much more complicated tasks than his predecessors. In one, an illuminated symbol (a triangle, square, circle, cross or X) appears in a small round window for five seconds, then disappears. About 20 seconds later the window lights up again, as do four others around it, each showing a different symbol. The monkey, in order to receive his food pellet reward, must push the symbol he first saw. The 20-second delay makes this a very difficult task for the monkey, who needs at least two months to learn it well.

The other task, though it is a difficult one for humans, is easier than the first one for the monkey. He must push a button on a rotating disk, by reaching through another disk rotating at a different speed so that the button appears at an always-changing location.

Human test subjects, according to one researcher, usually try to anticipate when the button will appear, then miss it when they can't second-guess its coming. The monkeys, however, have found the task surprisingly easy, and can score more than 80 percent of the time, even when the window disk rotates at 85 revolutions per minute and the pushbutton is visible only .2 second at a time.

This record may suffer considerably in space, however, the scientists believe. To accomplish its goal, the animal moves its head in a circular pattern at about the speed of the front disk. "This suggests that vestibular disturbances associated with rapid head movement in weightlessness may profoundly disrupt the performance," Dr. Adey says, "if frequent reports by astronauts and cosmonauts of disability in similar rapid movements provide a basis for comparison."

With such detailed criteria for flight, the National Aeronautics and Space Administration may have good reason to keep almost four times as many monkeys on hand as it does astronauts. In fact, although there are only 175 to 200 monkeys on hand at a time, the agency will probably have considered some 500 before it makes its final choice.

Most of the monkeys live in a colony at the agency's Ames Research Center at Moffett Field, Calif., about 25 miles from San Francisco. As they become more involved in the Biosatellite program, some of them move 375 miles south to UCLA's Space Biology Laboratory. In the last few months before the flight, the number at the lab will have grown to about 60. With six weeks to go, 15 of these will be selected for the trip to a specially prepared laboratory in hangar S at Cape Kennedy.

Nine days before the scheduled launch, the five healthiest, best-trained and best-dispositioned monkeys will be chosen for implantation of the complex biomedical instrumentation probes, which will yield 21 separate channels of data. The final candidate selection will be made with only 120 hours to go.

Before the monkeys ever get into the fine-combing process of the Biosatellite program, however, they are screened and quarantined for 45 days just to join the colony. Diet is plain monkey food, until a monkey is selected to join the experimental program, when he switches to the Biosatellite food pellet (the recipe of which is still being changed to control caloric intake and urinary sediments).

With mere food pellets receiving special research, other flight items have required major efforts. An automatic urine analyzer, for example, had to be designed from scratch. The result, $1.5 million later, has 12,000 parts in the space of a shoebox, yet it replaces several bulky pieces of equipment and a laboratory technician. It will measure, among other things, calcium loss from the bones, a problem noted in several Gemini flights.

A much broader problem has been simply how to fit all the equipment to the passenger. "The monkey's so smart, he'd take the spacecraft apart from inside if he could get at it," says an engineer with General Electric Co., builder of the Biosatellite. "There's been a terrible integration problem," agrees NASA's Biosatellite experiments manager, Dr. Rudolf Hoffman. Not only does the monkey have to be kept far enough away from delicate equipment in the cramped cabin so that he will not damage it, but room must also be left for movie cameras to record his actions, including his long simian reach.

Another problem has been waste disposal. Liquid wastes are no problem, but the researchers only now think they've got the solid-waste problem licked after two years of work. The chimps, Ham and Enos, were aloft for

. . . space monkeys

only a few hours, and so posed little difficulty. To take care of wastes for a month, however, without the human astronaut's ability to operate an active system, is another matter. For a while the scientists even considered equipping the monkey with a solid-waste-disposal device that "screwed right into the bone of his backside," says Dr. Adey. That idea has been replaced with a more comfortable one, however, in the form of a girdle-like harness.

The *raison d'etre* for the flight, of course, is biomedical information. The monkey will be instrumented with 10 electrodes to monitor brain activity, three for eye movements, four to measure electrical activity in the muscles, two for heart and respiration rate, one on each foot for galvanic skin resistance, one to take his temperature, and four catheters to keep track of circulation in the femoral and carotid arteries and in the right atrium and left ventricle of the heart.

So carefully has the instrumentation been designed, according to Dr. Adey, that even if spacecraft and passenger are not recovered, analysis of the information radioed back should provide 90 percent of the cardiovascular data, 30 percent of the metabolic data and fairly accurate evaluation of brain activity and circadian rhythms. Specially developed computer analysis can clearly reveal sleep cycles with only five minutes of data transmission per orbit. The researchers expect to be able to analyze periods of brain activity as short as one second, which can tell much about the monkey's decision-making activities.

Beyond the Biosatellites, NASA has even more elaborate monkey plans. Two companies already have contracts to design spacecraft capable of carrying a pair of primates, floating free and unrestained, in orbit for up to a year. With the Biosatellites having provided the detailed biomedical data, the later flights would study general long-term performance in space. The monkeys would live in relatively spacious quarters, attached to a manned Apollo workshop, until brought down by astronauts.

As with most animal researchers, the Biosatellite investigators are both concerned about the welfare of their subjects and wary from experience of the opposition that is almost inevitable whenever an animal is used in a scientific experiment. But they could hardly be more optimistic about the worth of their project. "A single successful flight," says Dr. Adey, "will yield substantially more data on the effects of prolonged weightlessness on the primate than has been gathered in all previous manned and unmanned flights."