SPACE MEDICINE

Still a mystery

Short stays in space have revealed few problems, but what the long-term effects will be, no one knows

by Barbara J. Culliton

Photos: NASA

Man in space: Not really a permanent resident yet.

Man is not inherently adapted for spaceflight. But against great odds and dire predictions that the weightless world of space would be hallucinogenic, or that it might even collapse his heart, he has determinedly proved his ability to fly beyond the earth's atmosphere, to walk in it and, imminently, to leave his footprints on the moon.

And yet, man in space remains a mystery. He can fly to the moon, as if for a two-week vacation, splashing down in the ocean afterwards. He can photograph the earthrise. But whether he can go to Mars or live in an orbiting space station for months or years is a matter open to debate. And though the financial crisis in the nation and the drama of man on the moon gives the impression that the flight of Apollo 11 is an end in itself, it is, in fact, merely a prelude to larger, and longer, adventures.

Realizing that adventure will depend, of course, on money and technology. And, to a greater extent perhaps than in the past, it will depend on the achievements of space biologists whose research will lay the foundation for man's survival in the alien environment. At present, according to the astronauts' chief physician, Dr. Charles A. Berry, space medicine is still "a rather primitive field of study where theories predominate and findings are often controversial."

However, now that space engineers have proved that they can do their job and that the emphasis on the technology of getting man aloft at all is somewhat diminished, the time has come for space biologists to move into the fore. Scientists with the National Aeronautics and Space Administration, researchers at more than 200 universities and advisory panels in the National Academy of Sciences are mounting efforts to answer the medical questions about man in space, with the exception that what they learn will benefit man on earth as well. "There is," says Dr. Berry, "no foreseeable end-point for space-related biomedical studies."

Ultimately, sophisticated information will have to be acquired about the effects of the space environment—weightlessness, perhaps, raises more questions than any other factor—on each of man's myriad physiological systems. Indeed, the list of specialists already involved to some degree in space-related investigations is as long and as comprehensive as a medical school catalogue. However, certain systems, selected partly on the basis of experience from Mercury, Gemini, Apollo and Russian missions, are, for now, prime research targets.

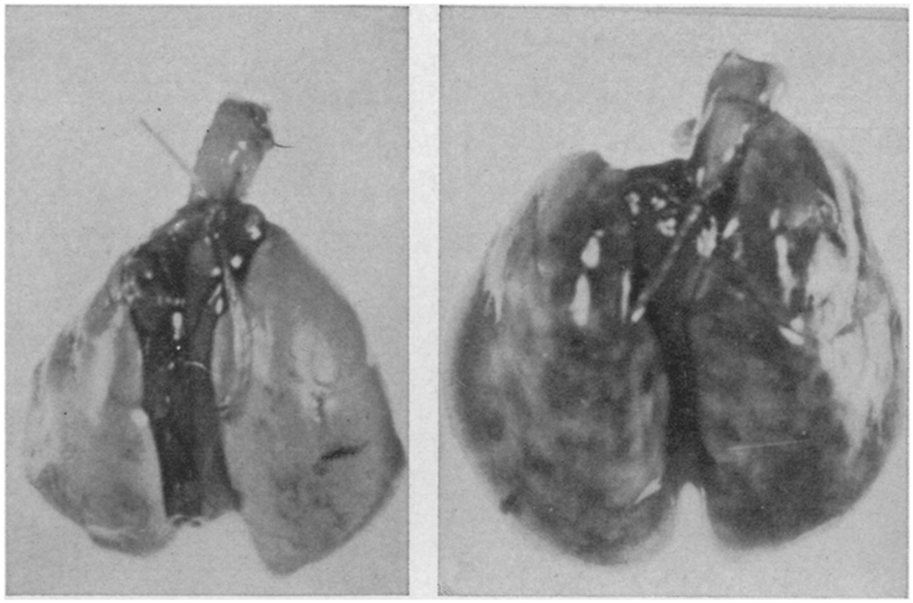
The absence of gravity clearly affects the cardiovascular system. No longer beating against the earth's gravitational pull, no longer subject to hydrostatic pressure, the heart has less work to do. This system, Dr. Berry notes, is the only one that has been investigated extensively, at least so far. Mercury and Gemini data (few biomedical tests were performed during Apollo orbits) show that changes in circulatory function appear within the first week of flight, and tend to remain stable afterwards, though the idea that changes are self-limiting is pure conjecture.

Loss of red blood cells is an example. First noticed on Gemini missions, this adaptive loss of cells was not anticipated by space agency biologists.

Dr. Berry: A rather primitive field.

In eight-day flights, astronauts lost as much as a pint of red cells—that is, bone marrow cells that manufacture red cells slowed production—but have lost no more during 14-day flights. "The tendency for the loss of red-cell mass to subside, and perhaps to level off as time progresses, is impressive," Dr. Berry observes, though he is unwilling to extrapolate this data for predictions of what will happen on extended journeys.

Dr. Herbert Shepler, secretary of the National Academy's newly formed Committee on Space Medicine, says there is some reason to believe that the pure oxygen atmosphere in the space cabin may account for red cell loss. "It



Rat lungs swell in pure oxygen: Left, a normal lung, right, after seven days.

is possible," he suggests, "that inert gases in the atmosphere may play a role in stimulating red cell production. Maybe nitrogen, in other words, is not as inert as we think it is."

Oxygen toxicity is another possible cause of cell loss.

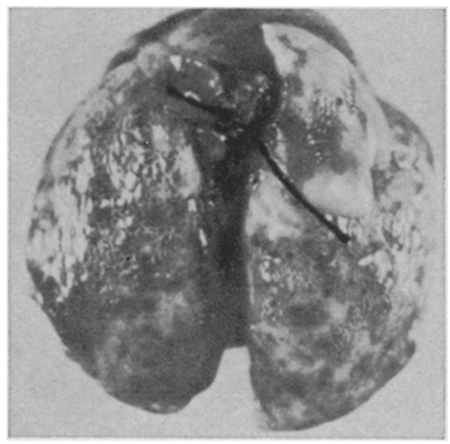
Dr. Shepler and other researchers also ponder the effects of weightlessness on cardiovascular tissue. While it is to man's advantage that his heart appears to adapt readily to less demanding zero-gravity condition, after long periods his heart and blood vessels could lose tone, becoming weak and flabby from lack of work, and this could be detrimental when he returns to earth.

Space affects other systems. Because bones and muscles are not called on to do as much work, calcium and muscle-building proteins are lost. Again, experience proves that this has no serious consequences in a two-week flight, but what might happen after a couple of months is unknown.

The skeleton could become so weakened that it could not withstand the shock of reentry and reexposure to the earth's gravitational pull.

Exercise and additional intake of calcium, and the occasional use of a centrifuge to provide some gravitational pull have been suggested as useful measures, but no one is sure whether or not any or all of these steps would work.

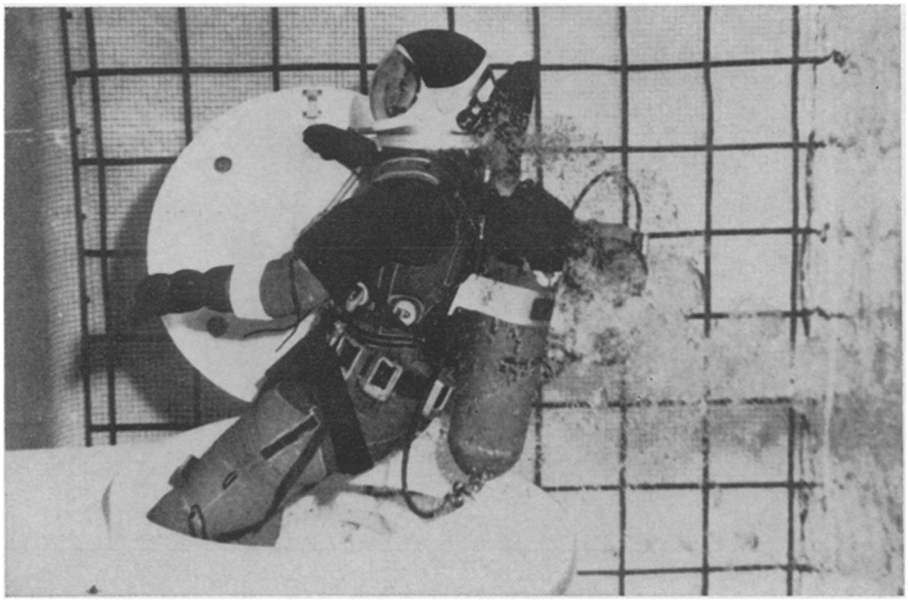
Respiration is also subject to the weightless state. According to Dr. Walton Jones, director of the NASA Biotechnology and Human Research Division, "The effects of gravity on the lung markedly alter gas and blood distribution. Weightlessness, on the other hand, affords the opportunity to study pulmonary function without this interference."



After 28 days: Severe emphysema.

One may be able to learn about the lung's response to stress by studying pulmonary activity in its absence. The reaction to oxygen pressure also appears to be important, and research in this area, conducted at the Ames Research Center, has fortuitously provided scientists with an animal model system for studying emphysema in man. Studies with rats, Dr. Jones reports, showed that exposure to 100 percent oxygen at sea level pressure for seven days swells rat lung tissue. The implications for man in space are negligible—"These pathological changes occur in the rat only with pure oxygen at a pressure over eight pounds per square inch, a much higher pressure than is being used in Apollo missions," Dr. Jones says—but the potential application of the rat for earth-bound medical research is great.

Answers to questions about man in space will undoubtedly be slow in coming because the number of opportunities



Water system simulates weightlessness, but is not practical for long tests.

for conducting experiments is limited by funds, by competition from physicists and chemists for chances to get room for experiments on various missions, and by technical problems in micro-miniaturizing equipment to make it practical considering the limited room available.

Establishing priorities is essential and space biologists are moving to do just that. One high-priority experiment, Dr. Jones reports, concerns the body's balance mechanism. "The experiment is essential if we are to understand the direct effect of weightlessness on a unique part of the body's balance mechanism, a part which is always under stimulation by the normal gravity force of earth." To study this phenomenon, frogs have been enlisted by NASA scientists for a Scout flight scheduled to leave from Wallops Island, Va., next spring. "In this manner we hope to begin to resolve the question of the need for an artificial gravity system in spacecraft prior to any consideration of interplanetary flight," he explains.

Planning for the experiment and development of suitable instrumentation has been underway for four years.

To examine the effect of zero-gravity on the otolith—the balance organ in the middle ear—microelectrodes will be implanted in the animals' vestibular nerves to measure the bioelectric potential during weightlessness and under gravity stimulation which will be provided repeatedly by a centrifuge.

Though scientists generally agree that it is risky to extrapolate too freely with animal to man in space, some experiments like the otolith investigation cannot be conducted in man, and biosatellites must be relied on for answers. The most recent, launched June 22 (SN: 6/14, p. 569), carries a monkey aloft for a month of detailed studies of everything from the density of his bones to the movements of his eyes. While he orbits the earth, the NAS will convene a two-week meeting in Santa Cruz, Calif., where scientists will attempt an extensive re-evaluation of the nation's space biology program. The result, hopefully, will be a highly specific long-range plan, outlining priority projects and distinguishing those that can be carried out only in space from those that might be conducted in specialized laboratory conditions right here.

But in the end, man will have to be his own guinea pig. Immunological data, for example, may be best obtained from human beings. In the closed spacecraft environment he is no longer exposed to the continual barrage of a host of micro-organisms as he is on earth, Dr. Frank Favorite of the NAS Committee on Space Biology points out. Two possibilities threaten. One is that those organisms he carries with him will proliferate, possibly even mutate, to cause disease. The other is that once back on earth, his defense will be so weakened that, like a patient on immunosuppressive drugs, he will be susceptible to microbes that he normally throws off.

Says Dr. Berry, "data must be obtained from an adequate sample (preferably six crewmen) for flight durations of six months in order to give prognostic capability for flights in excess of this duration." Such missions are planned in the Apollo Applications Program—preliminary schedules call for a 28-day and 56-day mission in 1970-1971—in which in-flight biomedical studies will be made by a doctor-astronaut. ◇