science news

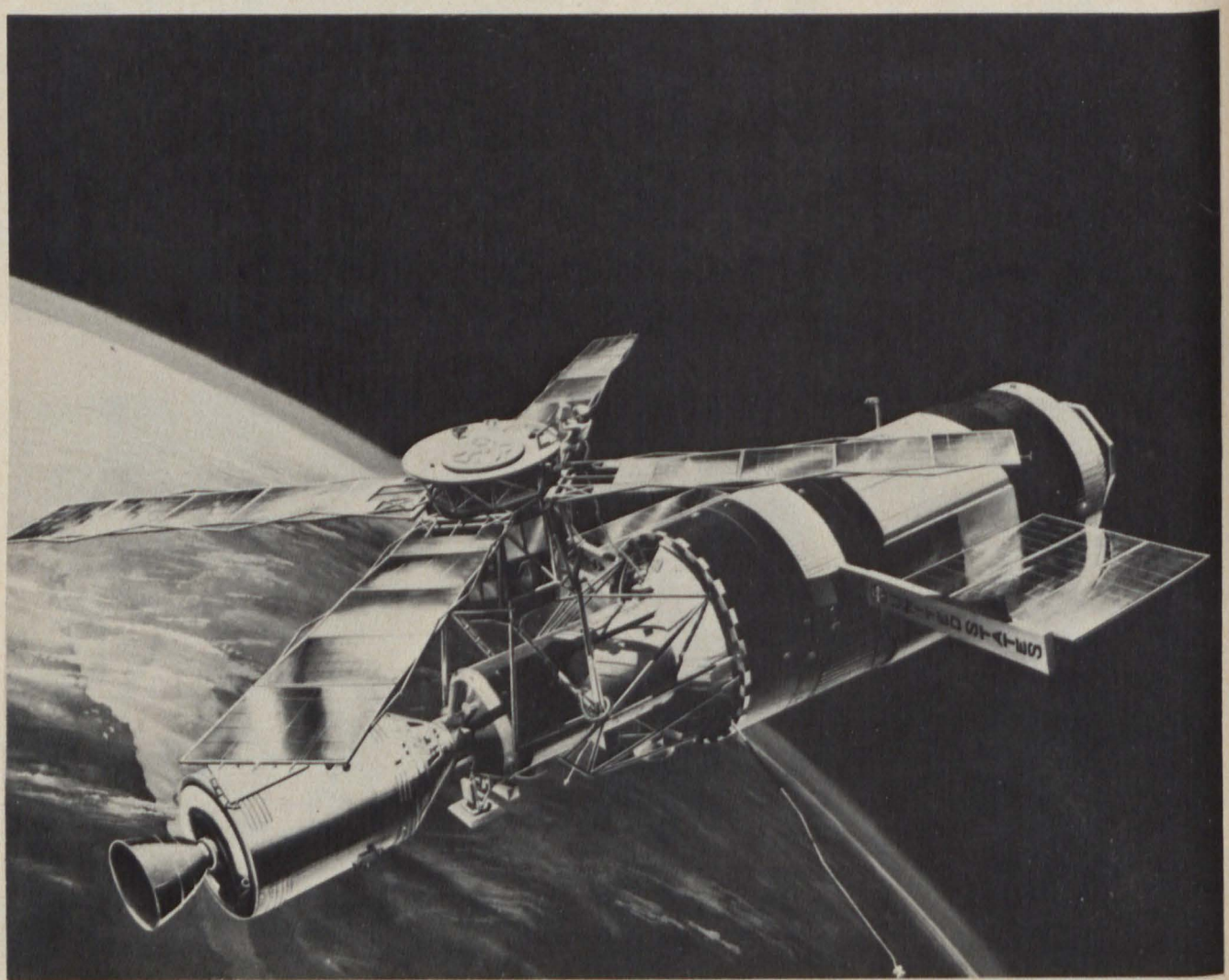
May 5, 1973
vol. 103, no. 18, 281-300

SKYLAB:
a special report

What we learn in space can improve the Earth.

Space search is the epic human search. Early earth orbits and Apollo's lunar landfall are yesterday's frontier, the end of the beginning for man in space. □ Now comes NASA's Skylab, the nation's first manned space station. A tool to measure and improve the balance between man and his resources, to increase and protect reserves of water, minerals, food and land, forest and clean air. A tool to measure man's ability to work in space for gains on earth in biomedicine, materials processing and vaccine research. A tool to examine man's and earth's dependence on outside influences through solar physics, astronomy, energy processes and sources. □ Skylab will spend 8 months in space as a laboratory for more than 70 major research projects in these areas. □ Martin Marietta Aerospace helped forge this tool by developing a multiple-docking adapter/experiment center, providing 4 experiments (including the astronaut maneuvering systems) and serving NASA as the integrator for the majority of all experiments aboard the space station.

MARTIN MARIETTA AEROSPACE



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COVER: Skylab, the first U.S. space station, will be launched May 14 and manned for 140 days over the next eight months. Nine astronauts, including scientists, will study the sun, other stars, earth and their own physical adaptation to weightlessness. See stories, beginning p. 291. (Drawing: NASA)

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COMMENT

The nature of scientific discovery

This has been a mind-expanding week of excursions through the world of scientific discovery, past, present and future. It began, for me, with a third pleasurable viewing of *2001: A Space Odyssey* and ended in discussions with the creator of "Star Trek." The days in between probed the 500-year history of science since Copernicus, whose birth was being commemorated with a series of inquiries into the nature of scientific discovery.

Roaming so freely over the intellectual milestones of discovery with the guidance of science philosophers and historians allows us to see science in a fresher and more honest perspective.

One observation to emerge is that science is much more closely related to the humanities than scientists readily admit or the public perceives. This misconception is no doubt due in great part to the misguided wish of many scientists to see and portray themselves as dealing purely in the cold, impartial world of objective fact rather than in the more subjective processes of their colleagues in art, literature, poetry and music. "Scientists are usually too proud or too shy to speak about creativity and 'creative imagination,' " Peter Medawar has written. "They feel it to be incompatible with their conception of themselves as 'men of facts' and rigorous inductive judgments."

Yet central to both science and humanities is the process of creativity. Here is a link that ties science with the rest of culture in a way that is at once ennobling and humbling to science. Those who feel alienated from basic science because they believe it deals solely with cold logic to the exclusion of more human processes should listen to Albert Einstein: "There is no logical path to these laws; only intuition, resting on sympathetic understanding of experience, can reach them." Another time Einstein wrote that certain axioms are "free inventions of the human intellect."

Says Gerald Holton, who has made a study of the thought processes of Einstein: "There is abundant evidence that the so-called intuitive leap . . . is guided . . . in Einstein, as in every scientist, by some strong preference, preconception, presupposition." This leads to a conclusion especially relevant today. As Holton puts it: "We now see that much of the fight of the priests of the counterculture against overly rationalistic science is a sham—it is largely a fight against straw men of their own making."

Another common bond between science and the humanities is in their substance and goals: Both, in their ways, help define, explore and understand the relationship of human beings to each other and to the world. Science, like philosophy, seeks to understand our role and place in the universe. Cosmology, with its quest for the ultimate beginning, seems at times indistinguishable from philosophy and even theology. The perceptions of Copernicus, Newton, Darwin and Einstein dramatically altered human awareness and have become as much a part of our cultural heritage as the plays of Shakespeare or as a timeless and profound work of art.

We all need to appreciate and, even more, enjoy science in this cultural context. A well-conceived and superbly produced 13-part film series written and narrated by the scientist-philosopher-humanist Jacob Bronowski titled "The Ascent of Man," ranges over the history of science in just such a way. It was shown for the first time last week during the Copernicus festivities in Washington. British television viewers will begin seeing it this month, and American viewers may get the same opportunity later. (Time-Life Films, co-producer with BBC-TV, is seeking a sponsor.)

"Ascent of Man" reminds us of the links between science and other aspects of human culture and portrays the legendary scientists as humans as interesting and worthy of attention as the giants of art and literature. (Galileo, persecuted for heresy, being visited and comforted in his blind old age by the poet John Milton. Newton secretly dabbling in alchemy and the occult. Einstein contemplating and discussing physics with his colleagues in a Bern cafe.)

The 500 years of discovery since Copernicus have revolutionized our view of the world. Yet there seems little doubt that, in physicist John Wheeler's phrase, "The greatest discoveries are yet to come." No one can say what those discoveries will be. But the most profound of those to come will help answer questions of equal concern to science, art and philosophy. Perhaps eventually even, as Wheeler puts it, "The greatest mystery of all, why there is something rather than nothing."

Kendrick Frazier

Stamp issued April 23.

Happy 500th, Copernicus!

An international symposium in his honor raises both disturbing and tantalizing questions about science

Sparsely attended, staid, but illuminated by occasional flashes of brilliance, the Copernicus quinquecentennial celebration in Washington last week raised disturbing questions about the endurance of the scientific process.

The formal program of lectures centered on exploring the nature of scientific research since its origins in the age of Copernicus, with several speakers expressing the fear that this "Second Golden Age of Science" might be coming to an end (see accompanying article). A new appreciation of the enigmatic figure of Copernicus also emerged from the sessions, though his essential character and reasons for hiding his great discovery remain shrouded in mystery.

Copernicus makes a natural subject for the sort of academic festival the National Academy of Sciences and the Smithsonian Institution sponsored: an astronomer in the ancient tradition who nevertheless initiated the modern scientific method and a humanist who symbolizes the ascent of Platonic philosophy, with its emphasis on observation and quantitative inductive reasoning. This is in contrast to the then-established Philosophy of Aristotle, which relied on acceptance of given principles from which the nature of things could be qualitatively deduced. Best of all, as one speaker noted, so little is known about Copernicus personally that he can be "petrified—turned into a great historical milestone" separating the ancient from the modern age of science.

In the best Renaissance humanist tradition, Copernicus described his own work as a rediscovery and continuation of earlier theories from the first "Golden Age" of science in ancient Greece. He shared the Pythagorean sense of the beauty of geometry and used this appreciation as a tool to build a new theory of the universe, with the earth going around the sun, rather than the other way around.

That he happened to be right was almost an accident. His new theory accounted for observed motions of the planets no better than the convoluted scheme developed piecemeal by astrologers of the time, and the final proofs had to await development of the telescope and, eventually, the direct observation, in the 19th century, of the earth's motion against the background of stars.

The multimedia display of intellectual fireworks assembled to celebrate Copernicus' birthday and demonstrate how well science has fared over the last half millennium varied as much in quality as it did in scope. Leading astronomers recounted the latest theories

Toulmin: End of an era for science?

Philosopher and historian of science Stephen E. Toulmin told audiences at the Copernicus celebration that the modern scientific era begun by Copernicus may be drawing to a close, halted by the same forces that killed the Greek scientific Golden Age.

The age of scientific excitement in antiquity ended, he said, when "the central philosophical and intellectual ambitions of science were abandoned as unattainable, and its inquiries fragmented into a dozen or more unrelated debates and bodies of technique; and when—secondly—the concern of the larger educated public with scientific ideas flagged and fell away, to be replaced by a preoccupation with technology on the one hand and with Oriental religions on the other."

As indications that the same forces are acting now, he cited a growing public disenchantment with science—the "Romantic Syndrome." He also condemned the turning away from scientific research as a way toward knowledge, in favor of "mission-oriented" technological projects, and the stultifying over-specialization among scientists.

If continued, he said, these trends could cause science to lose the "robust intellectual confidence" Copernicus brought to it so that "we may, in our own day, be in danger of witnessing the beginning of its fall." As for critics of science, he said, "If cities and factories use the earth's air and waters as an open sewer, that is not the fault of science."

Holton: The ecology of science

Another speaker to warn of imminent danger to the scientific process was Harvard physicist and science historian Gerald Holton, who saw disenchantment with science as only one part of a "rising new anti-intellectualism."

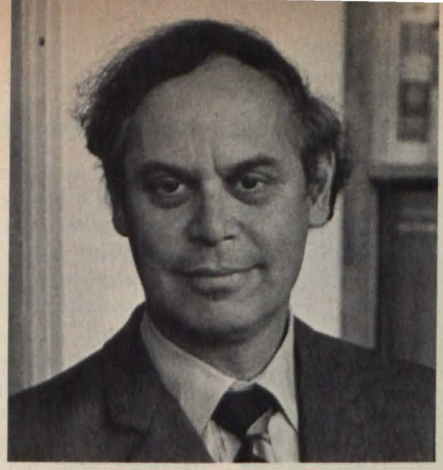
The progress of science, he said, is threatened by a loss of talented individuals now turning to other fields, the confusion and lack of understanding among the public that must ultimately support research, and the diversion by scientists of too much energy into practical technology "that may not yet be bolstered by enough basic knowledge."

But the most fragile element of what he calls the "intellectual ecology of science" is understanding by scientists themselves of the scientific enterprise, the great themes passed to this generation of researchers by those who went before. "Each time we make a speculative leap that is guided by such ideas as harmony, order, simplicity or necessity, Copernicus stands unseen at our side."

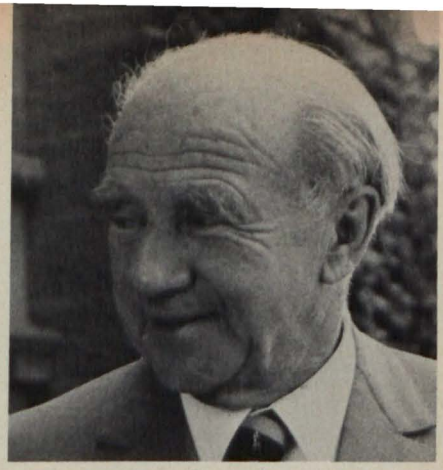
The preservation of this intellectual ecology, he said, rests on reassertion of the "professionalism" of science, the avowal to learn "what it is all about at the heart of things: to understand nature with no holds barred."

"Precisely because there is a rising new anti-intellectualism that would gladly see science decline" and because of generally declining of support for science he concluded, "*now* do we have to reassert, profess and celebrate our sciences more than ever."

Wheeler: Toward astrophysical theology. Solving the greatest mysteries.



Holton: The progress of science is threatened from many sides.



Heisenberg: Human reactions determine motives more than rational judgment.

about mysterious quasars and black holes. A church historian warned about the dangers of "space-angst"—fear of venturing off the earth—and later said he meant that people must move toward colonizing outer space, since "most scientists agree" that is the only hope for mankind's salvation. An economist in cowboy boots and string tie muttered about the size of his audience, saying he had expected to speak to "decision-makers," then rambled into a discussion of the need for people to help each other more.

Two concerts, including one consisting entirely of music commissioned for the occasion, were held in the auditorium of the National Academy of Sciences. Astronomer Fred Hoyle narrated the commissioned music, composed by Leo Smit to symbolize scientific discovery.

The program had something for everyone, including devotees of "Star Trek." Gene Rodenberry, who produced the popular television program and now hopes for a revival under a new name, told a mixed audience of scientists and "Trekkies" (as the young fans call themselves) about the potential for education in entertainment—particularly in science entertainment.

In its American premiere, the 13-part film series "The Ascent of Man" had to be shown in the absence of its creator, Jacob Bronowski, who suffered a heart attack just before he was to come to Washington. Four films of the series, sponsored by the BBC and Time-Life Films, were shown and received enthusiastic reception. In an address prepared to go with the film, Bronowski said his aim was to show the "romantic sense of humanism" of Copernicus, which influenced the way he pursued his work.

The series will appear soon on British television, but has not yet found a sponsor for showing in America. Parallel in some ways to Kenneth Clark's "Civilisation" series, "Ascent of Man" attempts to become intimately involved with its subject. For example, it takes the viewer first to the pub where Einstein argued relativity with friends and then on an imaginary train ride approaching the speed of light so he can experience firsthand the awesome physical reality of that theory.

The week's activities, Wilton Dillon of the Smithsonian said, "beautifully affirm" the ideas that brought them into being.

With spin-off in radio and TV taped programs, a colorfully illustrated book and a documentary film of the proceedings, he said, the impact would go far beyond the limited Washington audience. □

Heisenberg: Traditions and old friends

Recalling conversations with Albert Einstein and Enrico Fermi and old times in the Copenhagen "school" of Niels Bohr, Werner Heisenberg talked fondly and intimately about the birth of modern physics, modestly underplaying his own contributions. "Tradition," he said, "is both the condition for progress and hindrance" in science, inspiring the motives, directing the methods and supplying the hypotheses of the scientific process. But when old concepts and methods are insufficient, and words fail, tradition must be abandoned.

Heisenberg traced the web of personal friendships that led to the rapid successions of tradition-breaking discoveries in modern physics. As practical results of their work challenged moral tradition as well, the line between personal and professional relationships blurred even more. Heisenberg recalled, for example, how he once suggested to Fermi that the hydrogen bomb should not be tested and the latter replied, "But it is such a beautiful experiment." Such human reactions, Heisenberg said, often determine motives far more than "our rational judgment about the merits of various theoretical ideas."

Heisenberg predicted that a new understanding of nuclear physics and Einstein's unified field theory would come from the astronomy of pulsars and quasars. Asked if he thought Einstein, if he were alive, would now accept Heisenberg's view of quantum mechanics, he replied that in light of new knowledge, "I certainly hope he would agree."

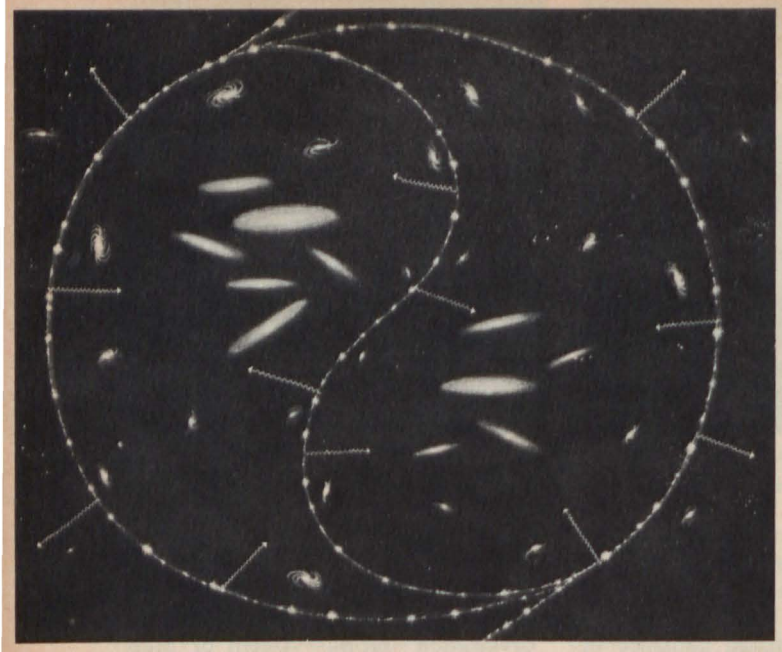
Wheeler: Participating in the universe

Perhaps the greatest reaction of the conference followed the paper, delivered by Princeton physicist John Wheeler, in which he set forth a philosophic view of science and man's place in the universe that one fellow scientist described as "approaching astrophysical theology."

By watching stars collapse into pulsars and finally into "black holes," Wheeler said, we see an "experimental model" of the ultimate collapse of the universe. In such a collapse, many of the laws of physics no longer hold—"not broken, but transcended." Noting that even slight variations in the values of physical constants would make life impossible anywhere in the universe, he said physical laws "are much more particular and relate to man the observer much more closely than one ever thought before."

As a result, man must consider himself a "participator," not just an observer, in the universe. Since this is the same point of view scientists have had to take in atomic research, where to measure is to change the system, Wheeler playfully suggested that this be called the "Merlin Principle" (rather than the Heisenberg Principle) because it keeps changing and reappearing in new fields of science.

Challenging those who would say the best is not still to come in science, Wheeler turned dramatically to a portrait of Copernicus on the stage and declared, "among all the humanities there is none more noble than science," for it can solve "the greatest mystery of all—why there is something rather than nothing."



Galaxies and antigalaxies: An artist's view of the symmetry of matter and antimatter in the universe. Gamma rays are produced at the boundaries between matter and antimatter.

NASA

Scientists believe they see evidence for antimatter

Some scientists now believe they see evidence for antimatter in the universe. The evidence is in the spectra of gamma rays taken during the Apollo 15 and 16 flights. According to a talk this week by Floyd W. Stecker of the Goddard Space Flight Center at the International Symposium and Workshop on Gamma-Ray Astrophysics, the gamma-ray spectra include emanations that appear to come from annihilation of matter and antimatter at boundaries between regions of matter and antimatter in the universe.

Antimatter is a standing problem for cosmologists (SN: 3/31/73, p. 211). Physical theory demands that for every piece of matter there be a corresponding piece of antimatter, but fitting antimatter into a big-bang universe is difficult. The first problem occurs shortly after the big bang starts: There would be quantities of matter and antimatter in close proximity, and they ought to annihilate each other. The universe could never get out of a state where it contains only the resulting gamma rays.

Slightly over a year ago Roland Omnès of the Laboratory of Theoretical and High Energy Physics at Orsay, France, showed that this difficulty could be overcome. A phase transition process similar to the formation of bubbles of vapor in a liquid could separate the matter from antimatter (SN: 2/12/72, p. 103).

Stecker and Jean-Loup Puget of the Observatory of Paris have gone on from there to show that by the time the universe had cooled off enough to have neutral atoms, the bubbles of matter and antimatter would have grown to the size of galaxy clusters. At this time, too, conditions would be favorable for supersonic turbulences to begin the condensation and rotation of the galaxies. The annihilations of matter and antimatter that took place at the boundaries between matter and antimatter would supply the energy for the formation and rotation of galaxies. Stecker and Puget find that they can account for the sizes, mean densities and rotational speeds of galaxies as a consequence of their theory. The theory also accords with the observational evidence in the Apollo spectra as well as certain other recent observations.

Stecker bases his observational argument on a "bulge" in the gamma-ray spectrum between one million and 100 million electron-volts. This is the range where Stecker expects annihilation gamma rays to show up. Although annihilation events in the laboratory give rise to higher-energy gamma rays, the boundary regions should be taking part in the expansion of the universe, and their gamma rays should be redshifted to lower energies.

Stecker's presentation at the meeting was an attempt to show that the bulge represents an extragalactic gamma-ray component that can be explained most plausibly as annihilation radiation. He subtracts all other possible gamma-ray sources and still has an excess. "It cannot be explained away," he says.

Others agree: "It is extragalactic," says Laurence E. Peterson of the University of California at San Diego. "Maximum correction still does not reduce it to zero," says J. I. Trombka of Goddard. "There is a consistency of time [from one observation to another] and a feeling of isotropy." "We have a good outline for a theoretical model," concludes Stecker. The revised High Energy Astronomy Observatory satellite will carry equipment to look into the question further. □

Pluto may be lying on its side

One night at the McDonald Observatory in Texas, Leif Anderson, a doctoral candidate at Indiana University, took time out from his observations of the satellites of the outer planets to look at Pluto. He was surprised at what he saw. Since the photometric observations in the early 1950's by Robert Hardie of Vanderbilt University, the characteristics of the light variations had changed—the amplitude had doubled.

The best interpretation of this increase, Anderson thinks, is that Pluto's axis is in the plane of its orbit. In other words, Pluto, much like Uranus, is on its side. Anderson says it will take several more years to determine the exact angle of Pluto's axis, but he's betting it is closer to 90 degrees than zero. He is submitting his data for publication in ICARUS. □

An untimely end to the Salyut spacecraft

The Soviets announced April 28 that the orbital scientific station "Salyut 2 concluded its program of flight"—leaving some observers to wonder exactly what that program was. All indications are that Salyut met with catastrophe.

According to spacecraft trackers, the station, launched April 3, had an accident April 14. Tracking data indicated numerous pieces of debris orbiting with the station. Speculations are that an explosion, or perhaps thrusters firing uncontrollably, ripped the four solar panels from the station, sending it tumbling through space.

The terse Tass account said only "the important data obtained in experiments confirm the correctness of design and structural decisions and properties chosen of the main systems and on board equipment. These data will be used in building new spacecraft."

This is not the first problem the Soviets have had with their Salyut space station linkups with the Soyuz spacecraft. The cosmonauts launched on Soyuz 10 were unable to enter Salyut once having docked with it. The cosmonauts of Soyuz 11 were successful in docking and entering Salyut, but they were killed on return to earth when their capsule developed a leak.

No one is sure exactly how these mishaps will affect the planned Apollo-Soyuz joint docking mission in 1975. It is assumed, however, the Soviets will want to have one successful Salyut-Soyuz mission before that time. □

Study finds science academy sometimes 'subverted by special interests'

The reporter who has conducted a two-year study of the National Academy of Sciences for the Ralph Nader organization has given an advance preview of the findings of two of his case studies. He says they indicate that the "independence and objectivity of Academy committees are often subverted by special interests."

Philip M. Boffey says the performance of Academy groups advising on the SST from 1965 through 1969 shows how sometimes committees "fall captive to the thinking of the government agencies which contract for their services." Other times, "as in the case of the Academy's Food Protection Committee, they fall prey to industrial interests." Boffey discussed the two case studies in a paper presented at the American Physical Society meeting last week in Washington. His book-length final report is undergoing review and updating and will be published later.

The general outline of advisory abuses on the SST and on various food-protection studies was not new. Much of the information has appeared in the public press over the years. But Boffey does provide additional documentation and detail.

He reveals, for instance, that two status reports to the Government in 1965 by the NAS committee on the SST and not made public at the time recommended, in effect, that the Government conduct a public relations campaign to persuade people to accept the SST. The committee, Boffey claims, had very quickly become an ally of the Federal Aviation Administration, which had contracted for the study, rather than an impartial adviser.

In the food protection area, Boffey notes that the committee "has long had very close ties with the food, chemical and packaging industries which use and produce the chemicals evaluated by the committee." He describes an instance in which a chairman of an Academy panel on MSG (monosodium glutemate) allowed his university research team to accept grants from the major producer of MSG "right in the midst of the Academy panel's deliberations" on potential hazards of MSG.

What Boffey did not say is that the Academy, well aware of such abuses, has taken at least half a dozen steps recently to root out bias and strengthen the integrity of the advisory process. All prospective committee members, for instance, are now required to fill out and sign a statement on potential sources of bias, and reports are now screened by a report review committee before publication.

Dioxin from defoliation found in Vietnam fish

By 1971, when the United States finally ended nearly a decade of herbicide spraying in Vietnam, as many as 5 million acres of the country were estimated to have been doused with various anti-plant chemicals. The most common was known as Agent Orange, half of whose active ingredients consisted of an herbicide called 2,4,5-T, short for 2,4,5-trichlorophenoxyacetic acid.

An accidental impurity produced during an intermediate stage in the manufacture of 2,4,5-T is 2,3,7,8-tetrachlorodibenzo-p-dioxin, commonly referred to as TCDD, or simply dioxin. Several past studies have suggested that concentrations of TCDD, fatal at some levels, can also cause birth defects in animals, which, combined with its stability in the environment, could mean that the impurity has greater potential danger than its parent herbicide.

In 1970, a special Herbicide Assessment Commission set up by the American Association for the Advancement of Science visited Vietnam for a first-hand look. As part of its work, the commission collected samples of several kinds of Vietnamese river fish and shellfish and of human mothers' milk, which were frozen in liquid nitrogen for later analysis. Because the apparently dangerous levels of TCDD are so small, in the range of parts per trillion, the samples languished for two and a half years while HAC director Matthew Meselson and graduate student Robert Baughman, both of Harvard University, worked out a suitably fine-toothed measurement technique.

Now they have succeeded, using a method of averaging repeated mass spectra over a period of time. The result is the first hard evidence that TCDD is indeed finding its way into animals—and thus into a food chain that could include man—in Vietnam.

TCDD was found in every one of the samples from both coastal and inland areas of Vietnam, but not in a butterfish from Cape Cod analyzed for comparison. The highest concentrations appeared in fish from the Dong Nai River some 50 miles northwest of Saigon. In those fish, mean concentrations of TCDD ranged from 522 to 814 parts per trillion. (Half of a test group of laboratory guinea pigs died from measured doses of 600 parts per trillion.)

An additional unnerving possibility is that TCDD may be able to form spontaneously from 2,4,5-T deposits left by spraying, perhaps due to the heat of fires or to photochemical reactions—reactions that may be related to those which lead to the impurity's forming during manufacture. Repeated experiments by Baughman suggest that—at least in a test tube—thermal reactions can indeed have that effect. Horst Langer of Dow Chemical Corp., main producer of 2,4,5-T, says, however, "We do not believe that it is likely, or even possible, that dioxins could be formed from 2,4,5-T under field conditions."

Studies by the U.S. Army and by the Herbicide Assessment Commission have revealed at least statistical correlation between the spraying and increase in stillborn children and birth defects in Vietnam. The evidence is purely circumstantial. But the human milk samples are next in line for analysis. □

Sabin links cancer and herpes virus

The herpes virus is a relatively common agent that causes fever blisters around the mouth and on the mucous surfaces of the genitals. In the early 1960's British scientists Michael Epstein and Y. M. Barr linked a herpes virus to a cancer (Burkitt's lymphoma). Since then herpes viruses have been implicated in Hodgkin's disease and cervical tumors (SN: 11/25/72, p. 345). The evidence, however, has not been conclusive.

Albert B. Sabin (developer of the live polio vaccine) has been working for more than 10 years to prove that cancer can be caused by a virus. Last week he and Giulio Tarro of the University of Naples announced that "under special circumstances" herpes virus can induce cancers. The proof, they said, has been hard to come by because once the virus does its work—produces a malignancy—it disappears. But, says Sabin, it leaves behind a clue that it has been there. A fraction of the virus' genetic material remains and reproduces with the cancer cells. This material stimulates an antibody that can be tested for. Tests were positive for this agent in patients with nine different kinds of cancer. Tests were negative for 20 other kinds of cancer.

Reporting on the work at the annual meeting of the National Academy of Sciences, Sabin noted that the herpes virus is something that the whole human population is infected with at some time or other. Therefore, he concluded, there is probably an important role for as yet unknown factors. □

physical sciences

From our reporter at the meeting of the American Physical Society in Washington last week

A puzzling abundance of antimatter

The proton-proton collisions that occur in the Intersecting Storage Rings at the CERN Laboratory in Geneva make available the largest amount of energy for the production of new particles of any laboratory apparatus on earth. For this reason the products of these collisions are searched for evidence of previously undiscovered particles.

A group known as the British-Scandinavian Collaboration did an ISR experiment looking for quarks. They found no quarks, J. M. Weiss reports, but they did find an unusual production of antideuterium nuclei. (Deuterium is the form of heavy hydrogen that has one proton and one neutron; antideuterium has one antiproton and one antineutron.)

The number of antideuterium nuclei produced was 60 to 1,000 times greater than at lower energies in conventional accelerators. Since antideuterium is a very loosely bound system, it is puzzling that it should be produced so readily as a single object. Production of free antiprotons and antineutrons would seem more likely.

In the tail of the nucleus

Most of the neutrons and protons in an atomic nucleus appear to be fairly evenly distributed through the volume of the nucleus, but there is an outer zone, a tail, halo or "nuclear atmosphere," that takes up the outer 25 percent of the nuclear radius, in which the concentration of particles gradually tails off. One of the important questions in nuclear physics is whether neutrons or protons predominate in this tail.

A rather naive reasoning would suppose that protons predominate in the tail, because they repel each other and so would tend to be pushed outward. But reasoning based on modern quantum theory indicates that neutrons predominate. An experiment by G. T. Condo, W. M. Bugg and E. L. Hart of the University of Tennessee and H. O. Cohn and R. D. McCulloch of Oak Ridge National Laboratory used slow antiprotons in a search for evidence of one or the other. The antiprotons, being negatively charged, are attracted to the nucleus. Being slow, they do not get very far into it, but undergo annihilation with either a neutron or a proton in the tail. Because of the charge difference between neutron and proton annihilation with a proton produces an even number of daughter particles; annihilation with a neutron produces an odd number. In the heavy elements tested (titanium, tantalum and lead), the results favor an excess of neutrons.

Nuclei with subnuclei inside

Another important question concerning large nuclei is whether each of the nuetrons and protons within them interacts equally with all others, or whether there are substructures, groups of neutrons and protons that are tightly bound to each other and interact with the rest of the nucleus as a group.

R. D. Schamberger Jr., Juliette R. Lee-Franzini and R. McCarthy of the State University of New York at Stony Brook and S. Childress and P. Franzini of Columbia University used protons of 200-billion-electron-volts energy at the National Accelerator Laboratory to look for evidence on the question.

Using events in which the projectile proton just grazed carbon nuclei, they found that significant numbers of deuterium and tritium nuclei were produced along with protons. The experimenters say that this may mean that deuterium and tritium are subunits of the carbon nucleus and that the ratio of deuterium to tritium to protons observed in the experiment reflects that inside the carbon nucleus. It could also mean that the projectile proton knocked some larger subunit out of the carbon, but that that subunit was unstable and decayed immediately into fragments. The deuterium and tritium observed would then give information about the unstable subunit.

No chemistry in neutron stars

Neutron stars, which are the highly condensed remains of the explosion of ordinary stars, are supposed to have a solid crust. Freeman Dyson of the Institute of Advanced Study at Princeton has proposed that chemical compounds, specifically a crystalline compound of iron and helium with the same structure as salt, might exist there.

If that were so then astrophysicists concerned with neutron stars might have to deal with troublesome astrogeochemical processes. Since the stability of the compound in Dyson's calculation was rather marginal, Thomas A. Whitten Jr. of Princeton University did a recalculation in which he included finer effects. These effects show that helium-iron compounds would be unstable.

Magnetic monopoles again refuse to show

Magnetic monopoles are one class of unfound particles that physicists now and then search for. Monopoles are necessary according to some physicists' belief in order to provide a complete symmetry between magnetism and electricity. Every electric phenomenon has a magnetic analogue and vice versa except for monopoles. Electric charges exist as monopoles (positive or negative), but the simplest known form of magnet includes two different poles, a north and a south.

At the National Accelerator Laboratory Richard A. Carrigan Jr., Frank A. Nezrick and Bruce P. Strauss used protons of 200-billion-electron-volts energy in an attempt to produce magnetic monopoles. The accelerator beam was directed onto an iron "beam dump." If any monopoles were produced in the interaction of the proton beam and the iron, they would stick to the iron because of their magnetism. After the iron had had a certain exposure to the proton beam, it was exposed to a strong magnet, which would serve to pull away any monopoles and impel them into counters where they could be recorded. No monopoles were found in more than 10^{15} proton interactions in the iron.

No quarks in the cosmic rays

Quarks are theoretically postulated particles out of which all the known subatomic particles of physics are supposed to be built. Some physicists think that free quarks should exist, and many searches have been carried out.

One place to look for quarks is in the cosmic rays. In 1969 C. B. C. McCusker claimed that he had found some quarks in the cosmic rays. No attempt to confirm his observation has been successful, and from Arnold F. Clark of the Lawrence Livermore Laboratory in California comes another negative result. Working with Donald E. Smith, Harold F. Finn and Norman E. Hansen, he examined more than 200,000 bubble-chamber pictures of cosmic-ray tracks and found, in the end, no evidence of quarks.

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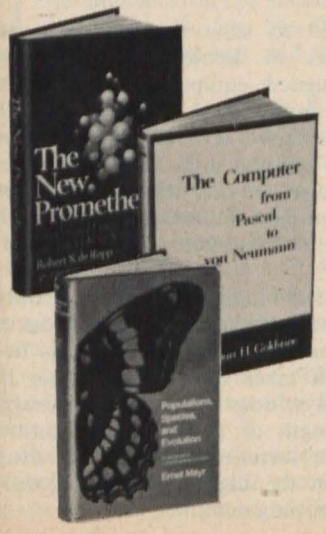

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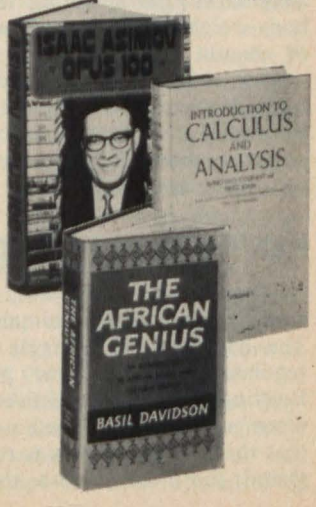


medical sciences

Heart attacks among young women

The American Medical Association reported several months ago that heart attacks in women under 45 are up 14 percent. David Spain of the Brookdale Hospital Medical Center in Brooklyn has found, on the basis of autopsy studies, that 20 years ago men under 51 were 12 times more vulnerable than women the same age but between 1967 and 1971, the ratio narrowed to four times as vulnerable. Researchers in other countries are getting similar results. In the past women below the menopause have not been very susceptible to heart attacks, probably because of hormonal protection. So why the increase now?

Spain thinks it is because more young women are smoking. Estelle Ramey, an endocrinologist at Georgetown University, agrees. "You virtually never see myocardial infarcts in women who don't smoke below the age of the menopause." Other investigators blame the increase on the use of oral contraceptives. This is the prevailing view at the National Heart and Lung Institute.

A relationship between the pill and high blood pressure was first noted in 1967. It has since been confirmed in other studies. One of the more recent was published in the Dec. 18 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION. Now, neurologists at some dozen universities report in the April 26 NEW ENGLAND JOURNAL OF MEDICINE that women on the pill are nine times more vulnerable to heart disease than are women not on the pill. This conclusion is based on studies of 598 women ages 15 to 44 with heart disease.

A plus for Pauling and vitamin C

Although 41 years have elapsed since vitamin C was identified, the amounts needed for human health are far from certain. Linus Pauling's assertion that humans need 10 times that specified by the Food and Nutrition Board has raised the roof of the medical community. The assertion has also sent biochemists to their laboratories to bear it out or negate it scientifically. One researcher reports findings in the April PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES that not only support Pauling's assertion but carry it further.

Man-Li S. Yew of the University of Texas at Austin tested guinea pigs for the effects of vitamin C on growth, wound healing and resistance to surgical stress. He found that 5 milligrams per 100 grams of body weight daily was necessary for the animals to grow well, heal quickly and recover from stress. Smaller amounts of vitamin C did not do the trick. Larger amounts did not seem to offer any advantages. Extrapolating these findings to children, on a body-weight basis, he estimates they need 1,500 milligrams of vitamin C daily.

Yew concludes: "The enormous discrepancy (nearly 40-fold) between this amount and that recommended by the Food and Nutrition Board calls attention . . . to an important public health problem related to the best development of young people."

How the brain regulates appetite

When the hypothalamus, a region of the brain, is damaged in experimental animals, they overeat and become fat. This has been the strongest evidence that the hypothalamus regulates appetite. Now psychologist Jaak Pankseep of Bowling Green State University reports that the hypothalamus may modify appetite by storing nutrients. He found that the appetite of rats is related to the amount of glucose stored; the more glucose, the less appetite.

behavioral sciences

Springtime for suicide

"April is the cruelest month, breeding lilacs out of the dead land, mixing memory and desire, stirring dull roots with spring rain," said T. S. Eliot. And he may have been right. William W. K. Zung of Duke University has found that spring is the peak season of the year for suicides and depression. The object of his research was to find differences and similarities between suicidal and depressed persons in order to help identify potential suicide victims and give them treatment.

From 1965 through 1971, 3,600 suicides were recorded in North Carolina. Approximately the same number of patients were admitted to the psychiatric service at the Durham Veterans Administration Hospital. Suicides and depression cases peaked in March and April and were lowest during the summer. April, for instance, had 327 suicides while July had 282. Zung also found that Monday had the highest rate of suicides of any day of the week. He concludes that "suicidal and depressed people feel out of step with changing seasons. They're dead inside, cold, empty. It's warm outside, alive changing. The contrast makes them feel out of step with the world."

Methadone and pregnant women

Children born to women taking heroin or methadone during pregnancy are sometimes born addicted to those drugs. A researcher at New York Medical College suggests that methadone may do more than addict unborn children. Alfred A. Smith (who has previously found that methadone prevents limb regeneration in salamanders) told the meeting of the Federation of American Societies for Experimental Biology that methadone retards the growth of baby mice by as much as 42 percent.

Newborn mice were tested because at birth they closely approximate the later growth stages of other mammalian fetuses. Half of each litter tested was injected with methadone. The other half was injected with a saline solution. Mice injected with 2 milligrams or more per kilogram of body weight not only gained less weight but also exhibited relative immaturity for their age. There was a delay in growth of coats, and the eyes opened at a later age. Smith admits there may be a different effect on humans but cautions against giving methadone to pregnant women because of potential harm to the fetus.

Alcohol, marijuana and muscle response

Various drugs are believed to slow response time in automobile drivers. Scientists at Brown University in Providence, R. I., have designed equipment to measure the neuromuscular responses involved. A subject sits with arm extended vertically and supports a weight. At random times the weight is dropped, causing a neuromuscular response. The stiffness of the arm muscle, the time it takes for the signal to reach the spine and return and the strength of the return signal are measured and recorded by a computer.

Paul R. Paslay reports that a moderate level of alcohol in the blood reduces the stiffness of the muscle and reduces the strength (but not the speed) of the return signal. Because this signal is weaker, it takes the muscle longer to respond. Marijuana, Paslay says, does not have statistically significant effect on the strength or speed of this return signal. But, he cautions, "we were not testing this drug (marijuana) for its effects on the higher centers (brain), which involve such matters as judgment."

SKYLAB

Focus on earth, the sun, the stars and man

Photos: NASA

by Everly Driscoll

The stepchild of the manned space program, Skylab, has finally become the principal heir and the center of attention.

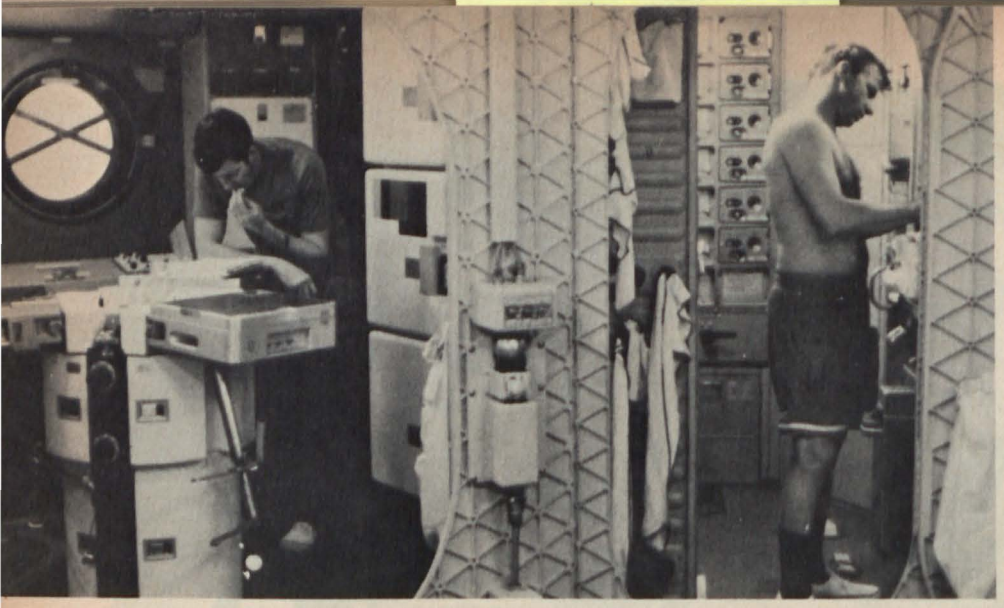
Ironically, the orbiting laboratory, first proposed in 1962 and now scheduled for launch May 14, might be one of the most important offsprings of the NASA space program. The missions should answer some basic questions about the ability of human beings to live and work for long periods of time in weightlessness and their inherent usefulness in space for research of earth, the sun and the universe. The results could profoundly affect the future of man in space.

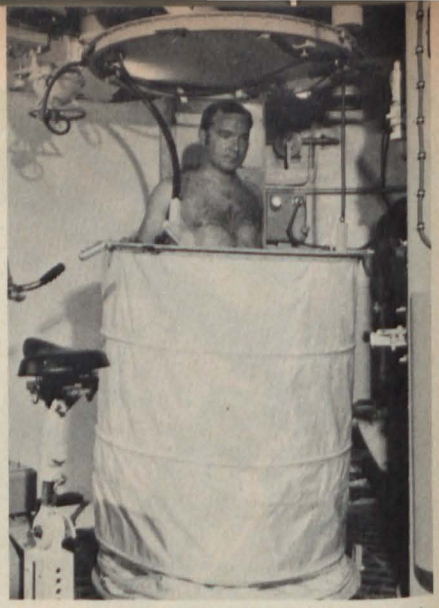
Heightening the anticipation was the launch last month of the second Soviet space station, Salyut 2 (see related story p. 286). But the untimely end of the Soviet space laboratory was of no comfort to U.S. space officials who were anticipating a useful exchange of information from Salyut and Skylab on earth resources photography, celestial studies and medical data.

Both space stations would have passed over the same areas of earth, but at different altitudes. Skylab will be 233 nautical miles above the earth and will pass over everything between 50 degrees north and 50 degrees south of the equator. The area includes 75 percent of the earth's surface, 90 percent of its population and 80 percent of its food producing areas.

Orbiting the earth every 93 minutes, the Skylab will be manned for 140 days from May to January 1974 by three separate three-man crews. The first mission will last for 28 days if all goes well with astronauts Charles Conrad, Paul Weitz and physician Joseph P. Kerwin. They are to be launched into space on May 15, a day after the laboratory is orbited. They will return to earth June 12. Then on Aug. 8, Alan Bean, Jack R. Lousma and Owen K. Garriot will take off to dock the laboratory. This mission will last for 56 days until Oct. 3. On Nov. 9 the last crew, Gerald Carr, William Pogue and Edward Gibson, will begin manning the laboratory, also for 56 days. Kerwin, Garriot and Gibson are scientists.

One key difference between the Skylab missions and Apollo is flexibility. "Skylab is subject to change at any moment," quips one NASA official. This





Kerwin in the kitchen (left), Weitz in the bathroom (center) and stand-in demonstrates shower setup (right).

flexibility includes the astronauts' schedule, called the "time line," which could, and probably will, be changed daily. It also applies to the lengths of the missions. If the men remain healthy and the laboratory and spacecraft remain in good shape, the missions will continue for their scheduled 28 or 56 days. If not, the men will come back to earth. The length of time between missions is also variable, depending upon the success of the previous mission.

The laboratory complex will be put into orbit by a Saturn 5 vehicle consisting of the Saturn 1C and Saturn 2 stages. In the space station cluster are the workshop (OWS), the multiple docking adapter (MDA), the Apollo telescope mount (ATM) and the airlock module (AM). On May 15, about 24 hours later, the first crew will be launched in an Apollo command and service module by a Saturn 1B vehicle. Conrad, Kerwin and Weitz will be placed initially into an 81 by 120 nautical-mile orbit. A series of engine burns will take the spacecraft to the 233-nautical-mile orbit of the laboratory complex. Seven and a half hours after launch, they will dock with the station. On the second day they will begin activating the laboratory and some of the 60 instruments on board. From then on they will live in the workshop.

The workshop is a converted third stage (S-4B) of the Saturn 5 launch vehicle. It has crew quarters and storage areas and it provides the structural support for the 45-foot solar cell panels which provide the electrical power. Built by McDonnell Douglas Corp., it is actually a two-story space cabin with aluminum grid-pattern floors and ceilings. The cabin is 48 feet long and 21

Living in style—a space motel with (almos

By Everly Driscoll

Open a can of beans and they float out of the can. Milk won't pour; liquid on a spoon tends to ooze around. Everything floats.

These seemingly minor examples are irritating, time-consuming and potentially lethal problems in space.

NASA and the Skylab contractors have made great strides over the Apollo way of doing things and have ironed out most of the kinks of living in space, but the crewmen of the space laboratory admit they are going to have to be careful in their movements and diligent in their housekeeping.

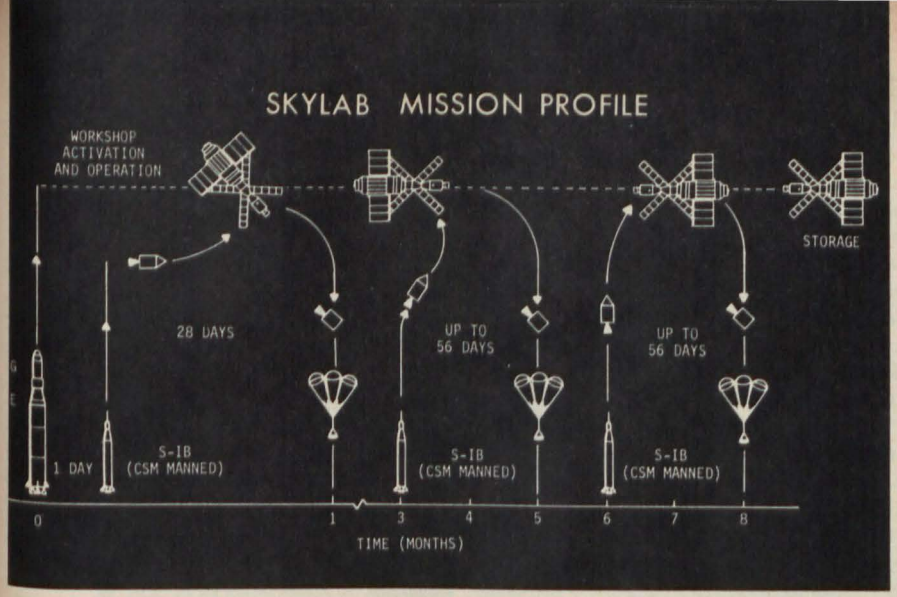
There is no up or down in weightlessness. "It will take us awhile to adapt," says Charles (Pete) Conrad, commander of the first mission. The astronauts have had 400 hours of training in the mockup lab on earth, but, admits pilot Paul Weitz, things will be far different in space. For example, in gravity the men usually stand beside an instrument to take the data. "It might be easier in zero gravity to hook the shoes into the ceiling instead of the floor and take the data upside down," quips Conrad.

The men can float from room to room, or use a fireman's pole to guide themselves head first. The pole cuts through the center of the two-story space cabin.

The luxury on Skylab of taking a shower will have little resemblance to showering on earth, but it sure beats the no-baths of Apollo. The shower is a collapsible plastic cylinder. The astronaut will unfold it, enter and spray himself with water, which will come out under pressure and be aimed at a suction drain near the feet. But water in weightlessness does not trickle down the body. It may stand still, or float up toward the mouth and nostrils. The men will have to be careful not to drown themselves. After the shower, the crewman will suck up all droplets of water with a vacuum cleaner to keep them from floating around the cabin.

Actually there won't be enough water for daily showers, and sponge-baths will be more common. The basin for washing the hands is simpler: the wrists are surrounded by rubber baffles that keep the water from escaping.

There is a law against spilling things—such as water—in Skylab, says Malcom C. Smith of the Johnson Space Center (JSC). NASA has spent considerable effort designing food containers that work more easily in space, take less time to use, and are filled with palatable food that doesn't kill the appetite. (The men should eat three balanced meals each day to off-set some of the effects of weightlessness such as loss of body fluid and minerals.) Membranes have been installed in the cans to restrain the food. Beverages will still have to be sucked out through a bit valve, a swallow at a time, but the food and drinks can be warmed or chilled in the ovens or freezer. The men will eat at a table off a tray. To keep from floating away they will place their feet in restraints. In times past, as Smith says, some food and liquid on Apollo wasn't worth the squeezing, but he thinks Skylab food, such as filet mignon, will suit the men. Three meals a day for one man costs about $26.35. Containers and all, there are 2,400 pounds of food in the kitchen lockers.



The workshop will be visited by 3 three-man crews from May through Dec.

Conrad changes earth resources film.

feet in diameter and has a total volume of 10,000 cubic feet. The crew quarters include sleeping compartments, a kitchen (wardroom), a bathroom (waste management compartment) and an experiment-work area.

The multiple docking adapter built by Martin Marietta provides the docking port for the Apollo command and service modules and houses the control panel for the telescope array. In this area is a large window for viewing the earth and performing some of the earth resources studies. The MDA is 17 feet long and 10 feet in diameter.

In between the workshop and the MDA is the airlock module. Through this room the astronauts will exit the laboratory to go into space to change the films on the solar telescope. The airlock unit also contains communications equipment, plus environmental, thermal, and part of the electrical systems.

The Apollo Telescope Mount has eight instruments for observing the sun in the extreme ultraviolet and X-ray portions of the spectrum and the sun's corona in the white light portion of the spectrum (SN: 1/27/73, p. 60).

The workshop, AM and MDA combined provide 12,763 cubic feet of space, about four times larger than the Salyut station and equivalent to a well organized three-bedroom house with a lot of closet and storage space.

Skylab is a resort hotel compared with Apollo. The crews will have sleeping bags, hot or cold food, hand-held showers, toilets and wash basins and exercise equipment. Stored aboard is enough food (2,000 pounds) for nine men for 140 days, as well as 6,000 pounds of water. The men will have a small book and music library and even a vacuum cleaner for housekeeping.

the comforts of home

Much housekeeping and cleaning up will be involved with food preparation and each man will take care of himself. "It's a concern," says Conrad. "We can't leave trash or crumbs to float around." Once-a-week-type chores, such as scrubbing the walls of the bathroom, will be assigned, says Weitz, "and done hopefully without bitterness or rancor."

The most relieving improvement over Apollo are the toilets. Both sit-down and stand-up facilities with suction devices replace the hand-held plastic bags.

Each astronaut will have his own sleeping compartment, clothing and personal hygiene kit. The sleeping compartment contains a chest of drawers, of sorts, for personal items and a sleeping bag attached to the wall. The bag is about the size of a narrow closet. He will go to bed by entering the compartment, turning his back to the wall, and zipping himself in. This keeps him from sleep-floating. A pillow is attached to the wall behind his head.

Skylab clothes may look like street clothes, but that's the only similarity. They are made of special fireproof material that cost about $30 a yard. A pair of boots, gloves, shorts, overshirts, jacket and trousers cost about $2,000. There is, however, nothing special about the underwear, says Larry Bell of JSC. "It costs 79 cents off the shelf." But fireproof outer garments must be worn over them. Skylab shoes have metal triangles on the bottom that pivot to fit into the grid-pattern of the floor or ceiling of the two-story cabin so the astronaut can hook on to stand still.

The clothing has been vacuum-packed to conserve space in individual modules for each man. There is enough for a change of underclothes every two days and outer garments once a week. If an astronaut wants to wear Bermuda shorts instead of trousers, he can zip off the legs.

When the clothing is dirty, it is thrown into the trash airlock which is actually the empty oxygen tank of the Saturn 4 stage. (The laboratory itself is a converted Saturn 4B.) The throwaway solution was chosen because of cost. "The zero gravity laundry development is something we haven't mastered yet," says Bell. Washing machines just weren't feasible.

One locker stores leisure-time activity items, although the astronauts aren't sure they will have time to use them: a Velcro dart board with blunted darts (also with Velcro on the end to cause them to stick to the board), books, headsets for some 60 cassette tapes, rubber handballs, playing cards made of fireproof paper and magnets to hold them onto the table. One thing the men will use for sure, they say: a pair of binoculars for viewing the earth.

All information about what the men eat each meal, the results of their medical tests, the exercise they get, the earth resources photography they take, what they do in their spare time and how they manage to adjust to weightlessness will be recorded and transmitted to earth. Their heart rates and sleep will be monitored. One thing the ground won't know about however: "Unless I am being lied to," says physician Joseph Kerwin, "they can't tell on the electroencephalogram what I am dreaming." □

All this is to ensure a normal life and routine for the men—if living in space can be called normal. Great attention has been paid to what NASA calls habitability—making the station roomy and as much like the comforts of home as possible. Each man will have leisure time daily to pursue his own interests—within the limitations of the current status of space life.

The work day will include tending the earth resources instruments and the solar telescopes and performing medical tests such as cycling an exerciser to allow evaluation of how the body is adapting to weightlessness (SN: 9/9/72, p. 172). Some time each day will be spent preparing food. The Skylab food (including lobster) is a far cry from the squeezed-tube meals of Apollo.

Conrad will, among other duties, be tending the space manufacturing experiments on board which include welding, growing crystals and forming spheres. "Mother nature can't grow a perfect crystal," he says, "but we think we can do it outside the influence of gravity." Space manufacturing is one of the more practical applications of manned flight, he thinks. The manufacturing tasks are designed to test the feasibility of electron-beam and thermal welding. Researchers also want to examine the flow of molten metal, freezing patterns, thermal time and surface tension for selected materials.

The primary goal of the first mission, however, is medical. Skylab scientists will study such matters as the crew members' mineral balance, bone density, blood, body fluids, heart rate and blood pressure. Electrocardiogram and vectorcardiogram measurements will be made, and crew members' sleep will be monitored.

Kerwin, the physician, will be involved in many of these tasks. If one of the men develops an infection, Kerwin will have on board the equipment to make a culture of the infection to see what kind of bacteria or virus is involved. He will be able to put the cultures in different drugs to determine the medication needed. A microscope will be on board.

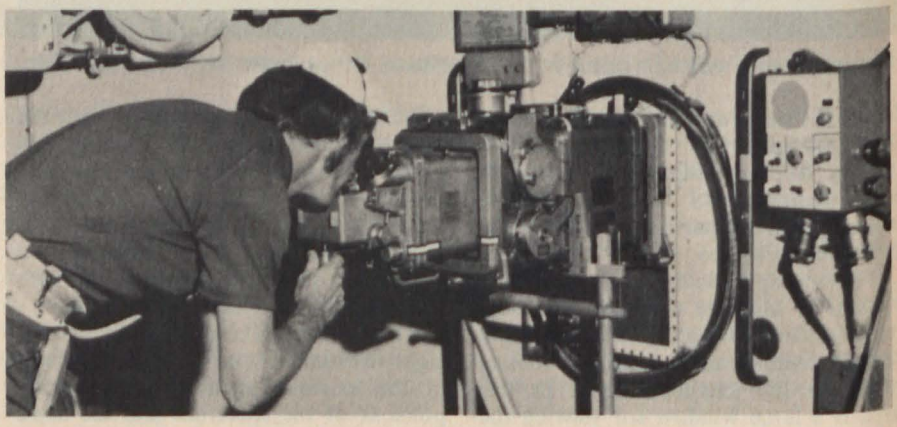
According to Conrad, the crew will be able to take care of anything short of heart attacks. Kerwin is equipped to do minor surgery such as tracheotomies. All of the astronauts have been learning to take stitches at the emergency room of a Houston hospital. They have been pulling teeth at Lackland Air Force Base. Pulling the teeth, says Conrad, is the most efficient way to cure a toothache in space. All of the astronauts "are at some degree between a nurse and a well trained person in first aid."

If one of the men should develop a serious response to weightlessness, the crew will return to earth in the Apollo command module or rescue module.

Space rescue is possible in earth orbit. If something should go wrong with the command module, NASA has a rescue procedure that involves launching another command and service module with two men aboard to retrieve the stranded crew. The rescue vehicle would be modified. Storage lockers would be removed to make room for a rescue kit which contains two more couches. There would then be room for five suited astronauts in the rescue vehicle.

Another key difference between the trips to the moon and the missions in earth orbit is communication. Rather than the constant air-to-ground chatter familiar to those following Apollo, most of the space talk will be taped. The crew will be able to talk to mission control live only when they are in line of sight of ground stations in Spain, Canary and Ascension Islands, Guam, Hawaii, Australia, Bermuda, Florida, California. Texas, Canada and the U. S. Navy's Vanguard. Depending on the orbit the crew will have from 15 to 25 minutes per orbit for live conversation. But the distribution of the ground stations is such that there will be some periods in which the crew will be out of real-time contact for two hours or longer—more than an entire orbit.

The Apollo program, with the glam-



Manned astronomy from space: Stellar telescope fits in airlock of workshop.

The personal dreams of many astronomers will be fulfilled vicariously on Skylab: Men with telescopes will be above the interference of the earth's atmosphere in an orbiting observatory viewing the sun, planets, stars, galaxies and nebulas. Sixty of the 270 investigations using 57 instruments on board will deal with astronomy and astrophysics.

Karl Henize is one of those earthbound astronomers. He is also an astronaut, however, and thus has filled a dual role in developing a telescope for use by man in space. Henize's work began at Northwestern University with James D. Wray who is now at the University of Texas in Austin.

The six-inch reflecting telescope with a movable mirror will be mounted in one of two scientific airlocks in the Skylab workshop. Targets are ultraviolet spectra of stars. The instrument's resolution and spectral range will fill the gaps between that of the Orbiting Astronomical Observatory 2 (SN: 9/2/72, p. 156), and its successor, Copernicus (SN: 1/20/73, p. 37). The telescope's main purpose is to study the differences from star to star in several of the strong spectral lines between 1,300 and 2,000 angstroms. The photographs will cover regions of the sky as large as 4 by 5 degrees with spectra of many stars on each photograph. Henize hopes to get about 150 pictures or more including about 50 star fields.

He is especially excited about studying oddballs of stellar astronomy such as Wolf-Rayet and flare stars. Wolf-Rayet stars have broad emission bands and are extremely hot. "They look like stars that have thrown off their outer layers, exposing their cores," says Henize. Only one such star so far has been studied in detail by the unmanned orbiting observatories. The Skylab telescope should get pictures of six more, some of which are rich in carbon, and others rich in nitrogen. "We don't quite understand why," says Henize.

Flare stars are faint red stars that occasionally and suddenly increase in brightness. The mechanism for this increase is not understood nor is why the flares are rich in ultraviolet. Most of them are quite faint. "We will be struggling to reach a couple of the brighter ones."

Three high-school students will also be getting data from this telescope on quasars, pulsars and T-Tauri stars. The students were winners in a nationwide contest which netted 3,400 proposals for use of Skylab. Of the 25 winners, 19 have experiments in the laboratory.

One of the X-ray instruments will be riding piggyback on Skylab—attached to the Saturn 4-B stage and operated unmanned. The piggyback mode was conceived back in the days when NASA viewed a launch schedule of 12 Saturn

our, excitement and importance of the first landings on the moon, is a hard act to follow. But earth orbital manned flights involve basic concerns—in fact vital concerns for man on this planet. From their revolving platform over the earth, the astronauts will have an overview of the health of the planet. The instruments will take the temperature of earth's crops, waters, forests and resources. The telescopes aboard will give scientists an intensive panorama of the sun, the source of energy on earth. And finally Skylab will measure man—his physiological and psychological ability to live and work usefully outside the earth's protective envelope. □

Astronomy on Skylab: The first manned orbiting observatory

4-B's per year. The X-ray mapper will be flown inside the rocket's instrument unit. When the stage separates from the command and service module, it will remain in orbit at an altitude of 120 nautical miles. The X-ray instrument—with a life-time of about 4 or 5 hours—will send data to earth. One-half the sky will be surveyed in the energy range between 0.2 and 12 KeV. William Kraushaar of the University of Wisconsin is the principal investigator.

A French telescope on Skylab under the direction of Georges Courtes, head of the laboratory of space astronomy at Marseille, France, will take an ultraviolet panorama of the sky.

In the Apollo Telescope Mount (ATM) alone there are eight major telescopes, two of which are for hydrogen alpha. Originally ATM was to be used only for studying the sun (SN: 1/27/73, p. 60), but because of some hard work by scientist-astronauts, such as Owen Garriot and Edward Gibson (both of whom will fly on Skylab), the X-ray, ultraviolet and white light telescopes of ATM will now also be used to study other stars as well.

ATM provides the structure for the telescopes as well as for some of the solar panels. The control and display panels for the telescopes are in the multiple docking adapter where an astronaut will control, monitor and point the instruments. A television sys-

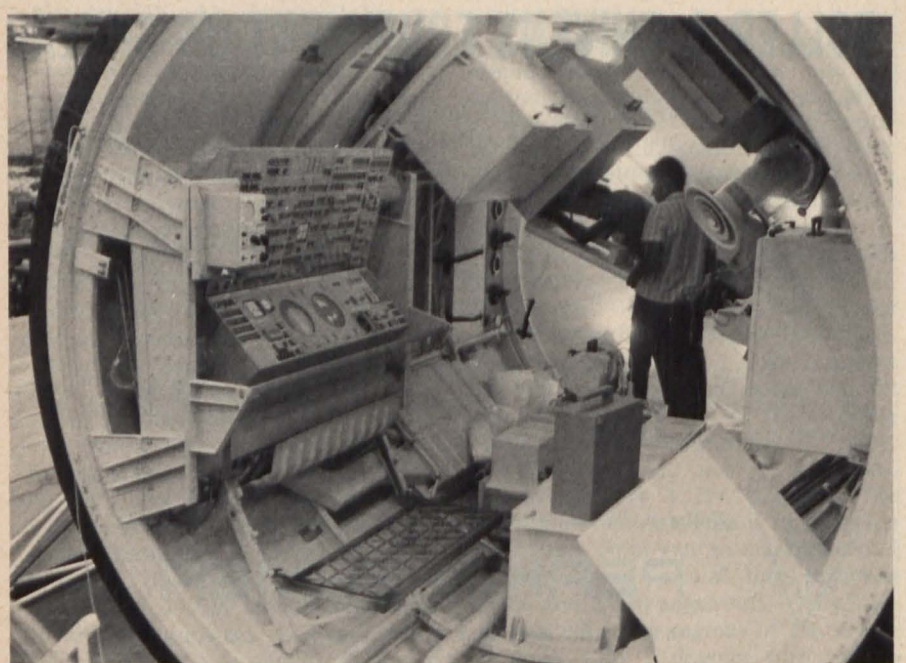
Conrad at the ATM console: "It's like playing three 88-key pianos at once."

tem will enable him to see images of the sun recorded by the telescopes. The array will get details of form and spectral composition of the sun not attainable by the orbiting solar observatory series (oso's).

Working the ATM is exciting but no easy job, says Charles Conrad, commander of the first manned mission. "It is like playing three 88-key pianos all at once." The astronauts will spend over 500 hours at the controls providing data for five principal investigators and 50 other astronomers around the world. Ground-based and sounding-rocket observations will be carried out simultaneously with ATM studies. Skylab scientists have established a worldwide communications network to inform ground-based observers of the daily schedule for solar astronomy.

One telescope not in the ATM cluster that will look at the sun is the X-ray ultraviolet instrument of Richard Tousey of the Naval Research Laboratory. The telescope will be mounted in the other scientific airlock of the workshop and will look at the sun in the region from 10 to 200 angstroms.

The ATM ultraviolet scanning telescope of Leo Goldberg of Kitt Peak Observatory and E. M. Reeves of Harvard College Observatory will also be used to look at celestial objects as well as the sun. It will observe emission lines in the region from 300 to 1,350 angstroms. "No one has ever looked at the stars in this region before," says Goetz Oertel of NASA headquarters. "It was computed that because of the neutral hydrogen absorption line nothing from the stars would be seen." He thinks that probably won't be the case.



Multiple docking adapter houses ATM controls and earth resources cameras.

The second ATM telescope to be focused on the stars and other sources is the X-ray instrument of Giuseppe Vaiana of American Science and Engineering Inc. The instrument operates simultaneously with the ATM white light coronagraph of Robert MacQueen of the High Altitude Observatory in Boulder. Any optical source (as well as structure) corresponding with the X-ray source can then be pinpointed. Many X-ray sources as yet have no known optical counterpart.

The mapper instruments for ultraviolet stellar astronomy, UV panorama and galactic X-rays should provide a comprehensive survey of the sky and allow astronomers to determine densities, spectral energy distribution and locations of many sources. The Skylab instruments will be able to observe more sources for much longer periods than rockets can. They will obtain better resolution than most of their unmanned orbiting counterparts, mainly because Skylab can take larger and much heavier hardware into orbit.

Orbital astronomy will focus on earth as well. Two prime targets are the day and nighttime airglow and the ozone layer. The astronauts will use a 35-millimeter Nikon with ultraviolet and visible lens. The upper atmosphere above 50 miles reradiates the sun's light to produce both the day and night glow. Changes occur in this radiation at twilight that have never before been observed. Donald M. Packer of NRL wants to find out, among other things, what physical processes occur during this transition.

The ozone layer prevents most damaging radiation from reaching the earth's surface. But the layer is tenuous and probably varies in thickness around the globe. Some questions scientists would like to have answers for: How do thunderstorms affect this layer? What contaminants, other than water, destroy it? Can the effects of high-flying jets be observed from Skylab? What underneath the layer is causing the variations? Do some cities, such as Los Angeles, have thicker layers?

Fate has provided a fitting finale for the U.S. first space station—the newly discovered comet Kohoutek (SN: 4/14/73, p. 237). In December during the last manned phase of the laboratory, the comet will be in a close approach to earth. While all eyes on the ground will be focused on the object, so will the X-ray and ultraviolet eyes of Skylab—a flaming exit for manned astronomy from space. □

Everly Driscoll

Conversation Pieces

Technically intriguing items from TRW, guaranteed to add luster to your conversation and amaze your friends.

Storm on the Sun In Einsteins's famous equivalence of mass and energy, $E = m C^2$, the C^2 turns out to be a very large number (186,000 mi/sec × 186,000 mi/sec). This means that the destruction of a very small amount of matter yields a very large amount of energy. The immensely destructive forces released by a small hydrogen bomb are dramatic evidence of this fact.

We can begin to appreciate the staggering amount of energy put forth by our sun when we realize that every second the sun converts 5 million tons of mass into energy and radiates it out into space. Light, heat, X-rays—in fact, the entire electromagnetic spectrum—stream forth from this hydrogen-fueled holocaust. In addition, subatomic particles such as protons and electrons are hurled into space carrying with them magnetic fields. This plasma, called the solar wind, blows through the solar system forming a kind of interplanetary weather.

Our own spacecraft earth courses through the solar wind much like a ship plowing through the sea. At its prow, the belts of radiation trapped by earth's magnetic field (the Van Allen belts) are buffeted then flattened by the solar wind and a bow shock wave is formed. Behind, an electromagnetic wake trails out for thousands of earth radii (see Figure 1).

Ordinarily the speed of the solar wind is relatively steady. Sometimes, however, a storm erupts on the sun, and the wind is whipped to hurricane proportions. When this occurs, the earth experiences the assault of a full-blown magnetic storm.

On August 2, 1972, an enormous storm, the largest ever measured in space, suddenly erupted on the sun. Flares leaped hundreds of thousands of miles above the solar surface, and huge discharges of plasma hurtled into space. As the storm slashed out through the solar system, NASA's Pioneer 9 satellite was in orbit between the earth and the sun; Pioneer 10, on its way to Jupiter, was travelling through the asteroid belt. The alignment of the two spacecraft had been anticipated by Pioneer engineers and scientists as an important opportunity to evaluate the normal flow of solar radiation. The giant storm was an unexpected bonus.

Pioneer 9 clocked the gust of solar wind at 2¼ million miles per hour. By the time it struck Pioneer 10, 76 hours later, the wind had slowed to around 1 million miles per hour. Interestingly, its temperature had shot up to nearly 2 million degrees, and the interplanetary magnetic field was 100 times its normal strength. The effects are suggestive of the magnetic "pinch" that scientists seek to control fusion reactions.

After settling down, the sun erupted again on August 7. During this storm NASA's Pioneer 6 satellite counted the greatest number of high energy particles ever seen, over 4,000 times more than normal. In a one hour period, the storm produced energy equal to the U.S. electrical power consumption for 100 million years. As an aside in parting, it warped the earth's magnetic field so severely that power and communication blackouts occurred in Canada, the northern U.S., Sweden and Alaska.

The data collected by these TRW-built satellites during the solar storms of early August are now being evaluated to determine their effect on current theories of the space environment, the earth's atmosphere, and other aspects of space physics. The information is expected to increase our understanding not only of our own star, the sun, but of other stars in the universe as well.

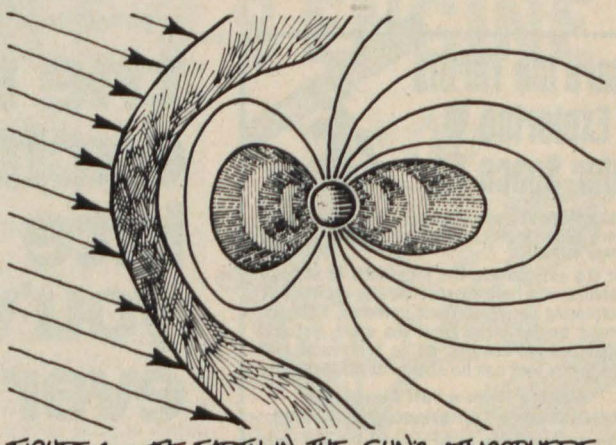


FIGURE 1. THE EARTH IN THE SUN'S ATMOSPHERE

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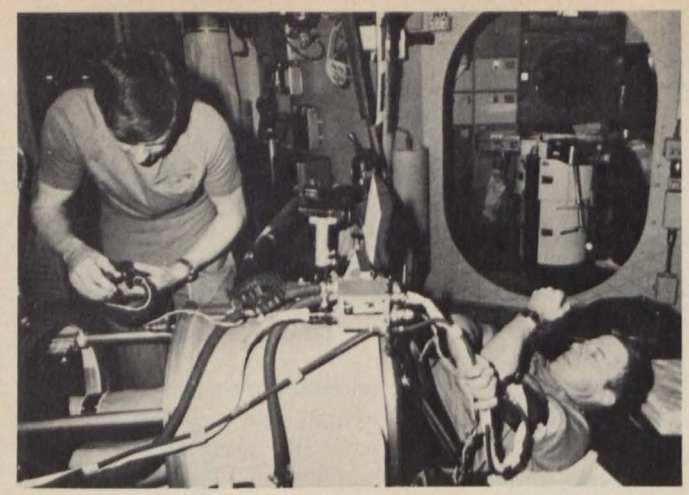

Physician Joseph Kerwin checks Paul Weitz on the lower-body negative-pressure-test instrument In space, the bathtub-like machine will measure the cardiovascular system's response to weightlessness.

Of mice and men—in space

"Man will be unsafe for 15 minutes in weightlessness; he will be unable to swallow or to pass urine."

Joseph Kerwin, the physician of the first Skylab mission, recently recalled these two dire predictions made in 1960 about the effects of space flight on man. Nothing so disastrous has happened. But the body does change, or adjust to weightlessness. The heart loses some of its ability to perform in earth gravity. The astronaut loses weight and exercise capacity. The body loses plasma volume and red blood cell mass. The muscles lose tone; the bones lose density. The heart decreases in size. There is an increase in leukocytes and renin activity. Catecholamine levels go up (SN 9/9/72, p. 173).

What is not known for sure are the mechanisms that cause these changes, or whether or not the changes continue, or eventually level off. Skylab should provide answers.

On the first mission of 28 days, the astronauts will spend about 30 percent of their time with 18 biomedical instruments. One is the scale. Because of the absence of gravity, NASA had to come up with a different method for determining weight loss. The scale is a platform which is put in motion. The astronaut will sit on the platform and his mass will be determined by the period of the pendulum platform.

An instrument that looks like a bathtub—the lower-body negative-pressure test—will determine inflight deterioration of the heart and cardiovascular system. A bicycle ergometer will be used to follow exercise capacity. Samples of urine, feces and blood will be taken and returned to earth to measure electrolyte, hormone and mineral changes. "We are looking at the body systems where we have seen changes in the past," explains Charles Berry, chief of life sciences at NASA.

One of the aims of the first Skylab mission is to verify the predictions made after the 14-day Gemini flight. If the predictions are correct, the biomedics can then extrapolate to the 56-day missions.

The men will not be the only living things on Skylab: Pocket mice and vinegar gnats are making the flight. From their response, scientists will know more about the effects of weightlessness on body or circadian rhythms.

Everly Driscoll

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ALCOHOL AND HEALTH: Report from the Secretary of Health, Education and Welfare—Mark Keller and others, Eds.—Scribner, 1973, 372 p., paper, $3.95. Up-to-date compendium summarizes current scientific knowledge on the health consequences of using, and especially of abusing, alcoholic beverages.

ASTRONOMY AND ASTROPHYSICS FOR THE 1970's, vol. 2: Reports of the Panels, Astronomy Survey Committee, NRC—Natl Acad Sci, 1973, 410 p., graphs, tables, paper, $14.25. These revised final reports present research programs, goals, priority projects, recommendations and statistical background material.

CITIES, THEIR ORIGIN, GROWTH AND HUMAN IMPACT: Readings from SCIENTIFIC AMERICAN, introd. by Kingsley Davis—W. H. Freeman, 1973, 297 p., photographs, diagrams, maps, $12; paper, $5.50. Shows man's adjustment to a wide variety of city living, from early ceremonial centers to Western industrialized cities and the metropolitan areas of the developing world.

CLEANING AND PRESERVING MINERALS—Richard M. Pearl—Earth Science Pub Co, 1973, 2nd rev. ed., 86 p., paper, $2.75. Deals with the four main aspects of preserving specimens—the stability of minerals, the nature of the individual mineral, the nature of the coating to be removed, and the purpose of the corrective procedure.

CONCISE GUIDE TO BIOMEDICAL POLYMERS: Their Design, Fabrication and Molding—John W. Boretos—C. C. Thomas, 1973, 202 p., illus., tables, $14.75. Handbook discusses the special biocompatible materials used in the fabrication of implantable prostheses, describes techniques and formulations in the context of their suitability to specific applications.

DIABETES EXPLAINED—Arnold Bloom, M. D.—Univ. Park, 1973, 152 p., illus., $6.95. The balanced control of diabetes depends to a large extent on the patient's intelligent cooperation. This book offers a clear and careful explanation of the disease and its treatment.

ENVIRONMENTAL SPACE SCIENCES—Donald G. Carpenter and others—Whitehall Co., 1972, 719 p., illus., paper, $10.95. Summarizes the elements of current knowledge in space science, from orientation in space, photons, particles and fields, solar phenomena, to geomagnetism, radio exploration, cosmochemistry, space dust, moon and planets.

FIBERGLASS BOAT DESIGN AND CONSTRUCTION—Robert J. Scott—De Graff, 1973, 144 p., photographs, diagrams, tables, $10. Addressing the small boat designer, the book discusses pros and cons of fiberglass as boat-building material, structural concepts, design and construction, cost, maintenance and repair.

MISSILES OF THE WORLD—Michael J. H. Taylor and John W. R. Taylor—Scribner, 1973, 167 p., photographs, $6.95. Up-to-date listing with standardized descriptions of all guided missiles known to be in service or under development.

THE NEW MORALITY FROM SCIENCE: Beyondism—Raymond B. Cattell—Pergamon, 1973, 500 p., $17; paper, $8. Psychologist's treatise concerned with the basic question of developing a morality *out* of science rather than bringing morality *into* science; states the principles of an evolutionary ethics, and considers the impact of the newly emerging values and the institutions required by them in the modern world.

THE OPTICAL MICROSCOPE MANUAL: Past and Present Uses and Techniques—Brian J. Ford—Crane-Russak, 1973, 205 p., plates, diagrams, $7.75. Book deals with the pioneers, elaborates on the development of the modern microscope, explains its action, parts and uses, and the preparation of specimens.

THE ORIGINS OF LIFE: Molecules and Natural Selection—L. E. Orgel—Wiley, 1973, 237 p., illus., $7.50. Written for student and general reader, shows the progress in studies of the origins of life, outlining the plausible mechanisms for most of the steps in the evolution of living organisms from inorganic constituents of the primitive earth.

PERSIA: An Archaeological Guide—Sylvia A. Matheson—Noyes Pr, 1973, 330 p., 63 plates, drawings, maps, $20. Written for both the serious archaeologist and the traveler, the volume covers more than 11,000 years of human settlements, including the well-known spectacular sites as well as current excavations.

SELECTING AND IMPROVING YOUR HI-FI SYSTEM—Harvey F. Swearer—TAB Bks, 1973, 224 p., photographs, diagrams, $7.95; paper, $4.95. Provides descriptions and specifications of home audio equipment, discussing the value and function of each component.

SENSORY NEUROPHYSIOLOGY: With Special Reference to the Cat—James C. Boudreau and Chiyeko Tsuchitani—Van Nostrand Reinhold, 1973, 470 p., photographs, drawings, $19.95. Describes the structure and function of mammalian sensory systems and their neurophysiological analysis.

THE SILENT DISEASE: HYPERTENSION—Lawrence Galton, introd. by Frank A. Finnerty, Jr., M.D.—Crown, 1973, 223 p., $5.95. A readable account of what is known about high blood pressure, what it is and what it does, symptoms, causes, and treatment. Appendix contains food tables and menus.

SPIES IN THE SKY—John W. R. Taylor and David Mondey—Scribner, 1973, 128 p., photographs, $6.95. Tells the story of the planes and satellites, and their cargo of cameras, television, infrared eyes and electronic ears that search the globe for new missile sites, radar installations and effects of bombings.

TRAVELER IN A VANISHED LANDSCAPE: The Life and Times of David Douglas—William Morwood—Potter, 1973, 244 p., 25 drawings, maps, $7.95. Biography of the 19th century botanical collector and his travels and discoveries on the North American continent.

WHAT IS THE GRAND DESIGN?—Peter Briggs—McKay, 1973, 215 p., $5.95. Puts in easily read form some of the findings of geologists, paleontologists and biologists, seeking to relate the changing geology of the planet to the continuously evolving life on it.

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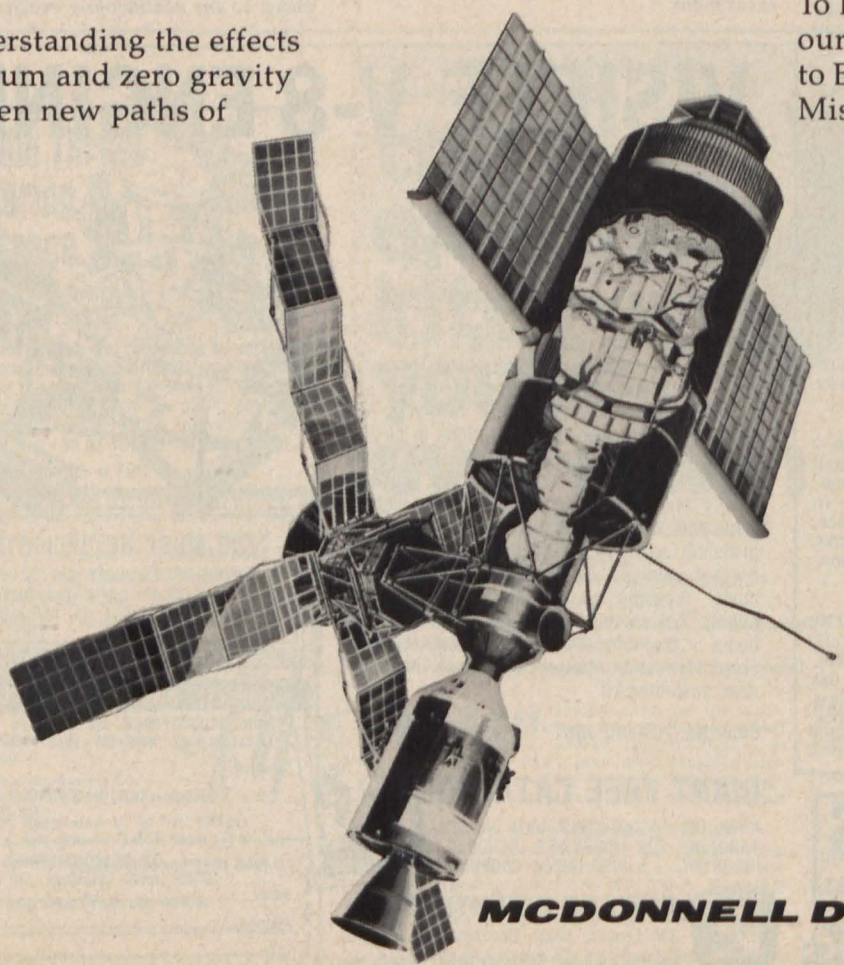

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