

Testimony of
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UNITED STATES SENATE
COMMITTEE ON COMMERCE, SCIENCE,
AND TRANSPORTATION
concerning
THE INTERNATIONAL SPACE STATION
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Mr. Chairman, Members of the Committee:

It has been ten years since I last appeared before this committee to testify on the International Space Station program. I began my 1993 testimony with a statement adopted by the elected Council of the American Physical Society:

“It is the view of the American Physical Society that scientific justification is lacking for a permanently manned space station in Earth orbit.” APS, 20 January 1991

The APS recently reaffirmed its statement, but the ISS, though still unfinished, is now in orbit. The question is, what do we do now?

A space station once seemed to be an inevitable step in the conquest of space. From such a platform it would be possible to relay communications around the globe, track weather systems, detect military movements, provide navigational assistance to ships

and planes, and study the heavens free of atmospheric distortion. All these things and more are now done routinely using unmanned satellites, and these robotic spacecraft are doing the job far better and far more cheaply than would ever be possible with a manned space station.

MICROGRAVITY

The International Space Station is an orbiting laboratory for the study of a microgravity environment. There are two quite separate justifications for a microgravity laboratory: One is to examine the biomedical effects of extended human exposure to microgravity; the other is to determine whether microgravity offers any advantage in manufacturing.

There had been speculation that certain manufacturing processes that are difficult or impossible on Earth might be easier in microgravity. For most manufacturing processes, however, gravity is simply not an important variable. Gravitational forces are generally far too weak compared to interatomic forces to have much effect.

A possible exception was thought to be the growth of molecular crystals, specifically protein crystals. The structure of protein molecules is of enormous importance in modern medical research. Protein crystals make it possible to employ standard X-ray crystallographic techniques to unravel the structure of the protein molecule. It had been speculated that better protein crystals might be grown in zero gravity. Unlike the interatomic forces within a molecule, molecules are bound to each other by relatively weak forces; the sort of forces that hold water droplets on your windshield. Gravity, it was supposed, might therefore be important in the growth of protein crystals.

Indeed, in the days following the Columbia tragedy, NASA repeatedly cited protein crystal growth as an example of important microgravity research being conducted on the shuttle. NASA knew better. It was 20 years ago that a protein crystal was first

grown on Space Lab 1. NASA boasted that the lysozyme crystal was 1,000 times as large as one grown in the same apparatus on Earth. However, the apparatus was not designed to operate in Earth gravity. The space-grown crystal was, in fact, no larger than lysozyme crystals grown by standard techniques on Earth.

But the myth was born. In 1992, a team of Americans that had done protein crystal studies on Mir, commented in *Nature* (26 Nov 92) that microgravity had led to no significant breakthrough in protein crystal growth. Every protein that crystallizes in space also crystallizes right here on Earth. Nevertheless, in 1997, Larry DeLucas, a University of Alabama at Birmingham chemist and a former astronaut, testified before the Space Subcommittee of the House that a protein structure, determined from a crystal grown on the Shuttle, was essential to development of a new flu medication that was in clinical trials. It simply was not true. Two years later *Science* magazine (25 June 99) revealed that the crystal had been grown not in space but in Australia.

Meanwhile, the American Society for Cell Biology, which includes the biologists most involved in protein crystallography, called in 1998 for the cancellation of the space-based program, stating that:

“No serious contributions to knowledge of protein structure or to drug discovery or design have yet been made in space.” ASCB, July 9, 1998

Hoping to regain some credibility, an embarrassed NASA turned to the National Academy of Sciences to review biotechnology plans for the Space Station. On March 1, 2000, the National Research Council, the research arm of the Academy, released their study. It concluded that:

“The enormous investment in protein crystal growth on the Shuttle

**and Mir has not led to a single unique scientific result.” NRC, 1
March 2000**

It might be supposed that at this point programs in space-grown protein crystals would be terminated. It was a shock to open the press kit for STS-107 following the Columbia accident, and discover that the final flight of Columbia carried a commercial protein crystal growth experiment for the Center for Biophysical Science and Engineering, University of Alabama at Birmingham. The Director of the Center is Lawrence J. DeLucas, O.D., Ph.D. If I go to the NASA web site and look for research planned for the ISS, I once again find protein crystal growth under the direction of the Center for Biophysical Science and Engineering and Dr. Lawrence J. DeLucas.

BIOMEDICAL RESEARCH

The microgravity environment has been found to be far more deleterious to human health than anyone had suspected. Indeed, in the first heady early days of the space age there was speculation that someday heart patients might be sent into orbit to rest their hearts, which would not have to pump blood against the force of gravity. On the contrary we find that not only is the heart severely stressed in zero gravity, osteoporosis, muscle atrophy, immune suppression, sleep disorders, diarrhea and bouts of depression and anxiety are endemic to the space environment.

By now you have all probably seen the “White Paper” by Dr. Lawrence Kuznetz that critiques the human life-sciences research aboard the ISS and the Shuttle. Intended as an internal critique for his colleagues, the paper was leaked to the public. Kuznetz, a professor at the Baylor College of Medicine, and flight projects research manager for a NASA academic consortium, finds that few if any of the experiments have valid controls. “The line between real and wishful science,” he writes, “is continually being blurred.” He puts the blame directly on NASA management. The stated objective of the life sciences research planned for the ISS is to develop “countermeasures” for the staggering

number of health risks facing astronauts, particularly those who might someday venture beyond the relative safety of low-Earth orbit. “Under the worst of circumstances,” he writes, “ISS will be in the ocean without a single countermeasure in the books for the cardiovascular, neurovestibular, pharmacokinetics, behavior and other major disciplines. Then again, we could get lucky.”

It is unfortunate that in our democracy, conscientious public servants, willing to risk their careers by leaking documents to the public, may be the only protection we have against self-serving and misleading public pronouncements by government agencies. What’s behind this is the NASA conviction that the public will not support a space program that does not involve putting humans in space. Research planned for the ISS is merely an extension of the sort of science conducted on the Space Shuttle over the past 20 years.

The research is not wrong, it is just not very important. No field of science has been significantly affected by research carried out on the Shuttle or on Mir at great cost. Much of it has never even been published in leading peer-reviewed journals.

The real objective of the most expensive science laboratory ever constructed is to provide astronauts with something to do. Ned Ludd, an English laborer who destroyed weaving machinery in 1779 to preserve jobs, would have cheered. But human progress is now measured by the extent to which machines are used to replace humans to perform tasks that are dangerous or menial.

Even if shielding is added to spacecraft to protect against radiation, and a long axis spacecraft is rotated to provide artificial gravity at great cost, the only conceivable new destination for human explorers is Mars. Conditions on other planets or their moons are too extreme for humans to ever set foot on them. They are too hot, or their gravity would crush a human, or radiation levels are much too intense.

Mars is no garden of Eden either, but the 1997 Pathfinder mission to Mars gave us a glimpse of the future. Pathfinder landed on Mars carrying a lap-sized robot named Sojourner. The tiny robot caught the imagination of people everywhere. Sojourner was a telerobot. Its brain was the brain of its human operator 100 million miles away on Earth. Its senses were the senses humans gave it. The whole world saw Mars through Sojourner's eyes. It had an atomic spectrometer for a nose that could sniff the rocks to see what they were made of, and thermocouples that could feel the warmth of the midday sun in the sand beneath its wheels. It never stopped for lunch or complained about the cold nights. Trapped in their space suits, human explorers could have done no more. Two much more sophisticated telerobots are now on their way to Mars.

Meanwhile, the exploration of space can't wait for astronauts. Our robots have already visited every planet save distant Pluto, testing the Martian soil for traces of life, and mapping the hidden surface of the cloud-shrouded planet Venus with radar eyes. Long before a human expedition to Mars could be launched, the robots will have finished their exploration.

We must ask what it means to "be there." Telerobots are robust extensions of their frail human operators, giving us a virtual presence in places no human could ever venture. The accomplishments of the astronauts on the ISS will be inconsequential. It is the scientists who control the telerobots, having become virtual astronauts, who will explore the universe. To explore where no human can ever set foot is the great adventure of our time.