ASGSB

Newsletter of the American Society for Gravitational and Space Biology

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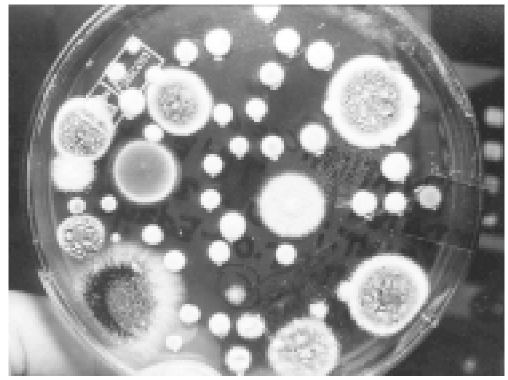
Dear Fellow ASGSB Members,

Welcome to the first joint American Society for Gravitational and Space Biology, Canadian Space Agency, and European Low Gravity Research Association scientific meeting. This meeting highlights some of the key issues for successful long-duration space flight. Three special symposia, with presentations from leading investigators, are planned: "Consequences of Contamination of the Spacecraft Environment," "Psychosocial Issues in Long-Term Space Flight" and "Current Ground-Based Models."



Consequences of contamination of the spacecraft environment will be the topic of one of the symposia at the joint ASGSB-CSA-ELGRA meeting in Montréal.

Contamination is a problem for any closed environment, but for space flight the difficulties are unique. Ultimately, the ideal life support system for a spacecraft will include plants and animals in an ecological balance–a balance that can be very difficult to achieve and that can be destroyed by unwanted contamination. Duane Pierson, William Shearer, Barry Glickman, and Jan Leach will discuss the different aspects of spacecraft contamination in Scientific Symposium One on Thursday. Investigators

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WELCOME!

ASGSB-CSA-ELGRA
Montréal 2000
October 25-28

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ASGSB President's Welcome

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interested in the health of both animals and plants will find "Consequences of Contamination of the Spacecraft Environment" a compelling session.

Providing medical care on a space station or long-duration mission has been a hot topic, with considerable ongoing debate about what kinds of surgical or medical support should be provided. Often overlooked in these discussions is the impact of psychosocial issues on long-duration space flight. Three crews have been evacuated from space stations, and in all instances, psychosocial factors played a role. In Scientific Symposium Two on Friday, "Psychosocial Issues in Long-Term Space Flight," experts on the psychological problems of isolation and confinement (Larry Palinkas, Judith LaPierre, Nick Kanas, and Gro Sandal) will present their views on this important and fascinating topic.

Flight research at NASA is at a difficult juncture. The Spacelab program, which provided outstanding flight research opportunities in the 1980s and 1990s, has ended. The Space Station, which will provide the research opportunities in the future, is not complete. Researchers interested in space biology will need to make the best use of ground-based models to advance their knowledge. In the mini-symposium on Saturday, "Current Ground-Based Models," David Klaus, Didier Schmitt, and Neal Pellis will present the advantages, and problems, of the models in use today.

This ASGSB meeting, as the first joint international meeting for the society, presents an excellent opportunity for researchers from around the globe to share their knowledge and results. Our joint meeting underscores the increasingly international nature of space research, in keeping with the plans for the International Space Station.

Marianne Cogoli-Greuter, Gerald Sonnenfeld, and Richard Wassersug have assembled a diverse and scientifically engaging program. All this takes place in the beautiful and cosmopolitan setting of Montréal. I hope you enjoy this opportunity to meet with colleagues and to share our findings in the field of space biology.

Sincerely,
Jay Buckey
ASGSB President

NASA Life Sciences Division Director Joan Vernikos Retires

Joan Vernikos, Ph.D., Director of the Life Sciences Division at NASA Headquarters, retired on August 31. Dr. Vernikos is well known throughout the scientific community, coming to Washington, D.C., from NASA's Ames Research Center (ARC) in Moffett Field, California. She joined ARC in 1966 after four years at Ohio State University Medical School where she was Assistant Professor of Pharmacology.

Throughout her NASA career, Dr. Vernikos held academic appointments at Stanford University, Wright State University School of Medicine, and was Visiting Professor at the University of London. She has published over 200 scientific papers and reviews, holds 3 patents and has served on the editorial boards of the *Journal of Pharmacology and Experimental Therapeutics, Endocrinology*, and was Associate Editor of *Pharmacological Reviews.*

Her research focused on understanding the hormone and behavioral mechanisms underlying the response to stress and applying that knowledge to operational conditions in aeronautics and space. For this work and her leadership in the space sciences, she has received numerous awards including the Strughold and the Leverett awards from the Aerospace Medical Association, The Jeffries award from the AIAA, and NASA's Exceptional Scientific Achievement and Exceptional Leadership Awards. She is a Fellow of the World Economic Forum.

In Memoriam

On August 24, 2000, Alexander Mashinsky, Ph.D., passed away after a long illness. Alexander had visited members of the Advanced Life Support and Space Biology community many times in the past, and had lectured during past Space Life Sciences Training Programs at KSC.

He was a renowned Russian space plant biologist and engineer whose focus was to develop simple plant growth systems that would support plants from seed to seed in space flight. One of his biggest efforts was the "Svetoblok," a small cylindrical chamber for growing plants in space. Both he and his wife, Galina, published a book on space biology, which is a compendium of all life sciences experiments conducted by Russian researchers in the last half of the 20th century. He is survived by his wife Galina and his son Alexander II.

Peter Chetirkin, KSC

Candidates for President-Elect and Governing Board Present Their "Vision" for ASGSB
Biographies Included

President-Elect Candidates

Stephen B. Doty, Ph.D., is Director of the Analytical Microscopy Laboratory, Senior Scientist, and co-Director of the Core Laboratory for Study of Skeletal Integrity at the Hospital for Special Surgery, New York, NY. His educational background includes receiving his Ph.D. from Rice University in 1965, a Fellowship at the NIH Cancer Institute in 1973, and a three-year appointment at the Dental Institute at NIH from 1975-78. His academic appointments include a position at Johns Hopkins School of Medicine, Baltimore, MD, followed by a staff position at Columbia University School of Medicine. Presently, in addition to the position at Hospital for Special Surgery, he is Adjunct Professor at the School of Dental and Oral Surgery, Columbia University, and Grant Professor of Biomedical Engineering, CUNY, NY.

Dr. Doty has published over 70 peer-reviewed scientific articles in the field of musculoskeletal research. He has been one of the pioneers in the study of the ultrastructure of bone and cartilage, including the description of the gap junctions between bone cells, the histochemical characteristics of bone and cartilage cells and matrix, and physiological studies of blood flow in bone. These basic studies formed the foundation for research into a variety of space biology flight experiments, which included Cosmos 1887 and 2044, Space Life Sciences 1 and 2, several mid-deck flights including STS-95 (the John Glenn flight), and Mir 21 / NASA 2 flight in which equipment and crew onboard Mir were utilized to carry out the experiment. Doty is presently preparing for an ISS experiment scheduled for 2001.

Dr. Doty is a founding member of ASGSB, has served in several Society capacities including the Board of Directors from 1995-98. He is a member of AAAS, the New York Academy of Sciences, and COSPAR. He serves on several ad hoc review groups for journals such as *Bone, Cell Biology, Journal of Physiology, Journal of Bone and Joint Surgery*, and *Orthopedic Research Society.* He has served also on several NASA and NIH review panels and presently is serving on the NIH Oral Biology and Medicine Review panel.

Karl H. Hasenstein is Professor and Graduate Coordinator at the University of Louisiana at Lafayette. He is a native of Germany and received his undergraduate and graduate training at the University of the Saarland. As a post-doctoral fellow he worked at the San Diego State University and at the Ohio State University before accepting his present position. He became Associate Professor in 1993 and was promoted to Full Professor in 1997. He was selected as the University of Louisiana Distinguished Professor in 1999.

Dr. Hasenstein has numerous research interests. His interest in the regulation of plant growth ranges from mathematical modeling to the localization and distribution of hormones and their receptors, and the function and regulation of the cytoskeleton. Since 1995 he has been working on a shuttle experiment (to be flown on STS-107) that studies the gravity sensing and response mechanisms of roots. One of the goals is to verify that physical displacement of amyloplasts by a force other than gravity (high gradient magnetic fields resulting in magnetophoresis) causes a response similar to gravitropism. This project included the complete development of new and unique hardware. A second NASA-funded project concerns the characterization of the cytoskeletal organization in another model system, the *Chara* rhizoid. NSF and DOE-funded research include aspects of salinity effects on plant growth and the elasticity and composition of the cell wall. Dr. Hasenstein has served on NASA peer review panels and NSF policy-forming workshops. His research has resulted in more than 50 peer-reviewed papers which he has been invited to present throughout the US (including two Gordon Conferences), Europe, and Asia.

Dr. Hasenstein has been a member of ASGSB since 1986, chairs the Long-Range Planning Committee and has served on the Governing Board from 1997-2000. He initiated and evaluated a recent survey of the membership to develop a better understanding of the sentiments and future directions of the membership of ASGSB. He is a member of several professional societies including the American Society of Plant Physiologists, Japanese Society of Plant and Cell Physiology, Scandinavian Society of Plant Physiology, Sigma Xi, and COSPAR, where he served as editor (Nagoya 1998) and program organizer (Poland 2000).

President-Elect Candidates Present Their "Vision" for ASGSB

ASGSB Vision Statement: Stephen B. Doty

In the pre-ASGSB years, Dr. Thora Halstead required all her NASA grantees to convene once a year to exchange scientific information and space flight experiences. These informal meetings gradually grew in size and scope until it was obvious that a formal organization was needed to handle these meetings and make them a much broader based educational forum, so the ASGSB was formed. Through the efforts and commitments of the previous leadership, the Society has developed a strong educational program and influenced many of NASA's research programs. It is critical to continue to expand our activities in these two areas. But in addition, I would suggest two rather simple actions which I believe will strengthen our present Society: (1) Increase our total membership in the next two years by reaching out to those who can provide us with a broader scientific base, and (2) Increase our collaborations with other societies and organizations interested in space-related science, especially the NASA research centers.

ACTION 1: The ASGSB has maintained a membership of about 350-400 members for the past several years. And though we have become more active and better organized during those years, we are not growing in size nor are we reaching all the scientists involved in space research. Each of us know scientists who have NASA-funded grants who do not belong to the ASGSB and often do not know about the existence of this Society. This is not a problem to be solved by the Membership Committee alone, but through a concerted effort by us all. In addition, further outreach into other scientific meetings should be initiated by the ASGSB Board or Society members. Then, as we increase the size of the membership we will also be increasing the number of representatives from a broader base of science than we have now. To increase our exposure to other disciplines of science can only strengthen our Society and improve our overall ability to carry out good space-related research. Today, we are truly a small Society. Smallness is great when only specific areas of science are being discussed, but with the competition for research dollars and competitive challenges among scientific disciplines, the ASGSB needs to collaborate with other disciplines to enhance our science and to educate the scientific community about our interests in space and microgravity research.

ACTION 2: While developing interactions with other societies and organizations we must also strengthen our relationships with the NASA centers. Both the Centers and the Society could benefit from greater scientific exchange and increased mutual involvement in space-related activities. Historically, the various organizations interested in Space Science operated independently of each other. I would stress that now, more than ever, with limited budgets and relatively small numbers of people actually involved in Space Science, that we must have more collaboration, both scientifically and politically, if we are to remain an effective Society.

ASGSB has slowly evolved from the initial form that Thora Halstead envisioned, to a society with much more political and educational activity than any of us thought would be possible or necessary. We have left behind the good old days and greatly enhanced the original scope of our Society. Now we must continue to advance our cause by increasing our scientific base; improving communication between ourselves, NASA, and other scientific agencies; and increase and improve our own scientific efforts. The Society must decide in the next few years, how much of this growth they are willing to commit to, and how hard they are willing to work to achieve it. We have the leadership to help us reach our goals, but no decision will be effective unless all the Society members take an active role in plotting the course.

ASGSB Vision Statement - Karl H. Hasenstein

The decision to offer my services as President of ASGSB resulted from long-term observations and involvement in ASGSB and the realization that we do not yet play the role we should in the landscape of scientific societies. Scientists are known and appreciated for their sense of independence, creativity, and thoroughness. I intend to tap these resources to promote the recognition, influence, and quality of ASGSB.

No other society has a membership as special and unique as ASGSB, namely a tremendous wealth of experience and knowledge about the most pervasive force in the evolution of life, gravity. This uniqueness is paired with an equally impressive breadth in experimental and technical knowledge gained from developing diverse projects, and excellent training. I am convinced that developing scientific quality, promoting academic and public education, and recruiting new members will improve the viability and influence of the society.

Among the many issues that concern scientists represented in the ASGSB, three are most important to me:

The first concerns the advancement of ASGSB as an authoritative society for gravitational biology. The society was founded as an exchange for space biology. In the early years it grew rapidly, mesmerized a new generation of scientists, myself included, but became stagnant as the funding for space biology declined. The resulting revitalization of space biology occurred without increasing the membership and influence of ASGSB. I believe it is a worthwhile objective trying to make ASGSB the professional shelter of all scientists involved in space biology.

Second, the long awaited and often jeopardized International Space Station demonstrates that space, the last frontier, cannot be successfully explored by one single nation. The same principle is true for science and scientific societies. The broader the exchange, the greater the mutual understanding between scientific and commercial endeavors. I believe it is vital for the American Society for Gravitational and Space Biology to team up with international societies and spark scientific and political engagement at home and abroad.

Third, last year's questionnaire clearly indicated that the membership of ASGSB views the Society primarily as a forum for scientific exchange and education. Although education must include the public, and the opinions of political decision makers, the best service is to provide strong incentives for students, from undergraduates to post-graduates, to pursue space biology and membership in ASGSB. The stronger the presence of space biology on campuses and universities, the better the foundation for future space scientists and the more meaningful the service that ASGSB can provide.

I believe that ASGSB will be served well by strengthening our scientific mission, fostering international collaboration, and promoting the education of and a professional shelter for future space biologists.

Governing Board Candidates Present Their "Vision" for ASGSB

Jeffrey R. Alberts is Professor of Psychology at Indiana University, Bloomington. As a developmental psychobiologist, he has been a PI on a variety of space flight experiments, including Cosmos 1514, NIH.R1 and NIH.R2, all involving the developmental and reproductive biology of mammals. As President of STAR Enterprises, Inc., he continues to develop the rodent habitats for the International Space Station.
Vision statement: The ASGSB is a small, intensely multi-disciplinary organization. Multi-disciplinarity is both a virtue and a necessity in our Society. Much of our research involves the use of shared facilities (e.g., large centrifuges, the Space Shuttle, and the imminent Space Station) and shared specimens. The success of our science depends, in part, on our ability to appreciate methods, goals, and trends in disparate fields and to achieve productive convergence and collaborations. Lobbying Congress remains important, but I think we should increase such efforts within NASA: We should capitalize on NASA's promotion of the life sciences, and help the agency find ways of enhancing our research opportunities. In addition, I would like to invite the nascent field of Astrobiology to join us, with the goal of broadening the purview of that discipline to include interests of ASGSB members.

Christopher S. Brown is the Director of the NSCORT in Gravitational Biology at NC State University and a Senior Scientist with Dynamac Corporation. He has authored papers on plant growth and metabolism in space. He teaches an undergraduate course in Space Biology at multiple universities using classroom and online resources. He has been a member of the ASGSB since 1989 and serves on the Education Committee.
Vision statement: It is widely recognized that a thorough understanding of the impact of gravity and the space environment on biology is essential for the success of all human missions, and many robotic missions, to space. As one of the foremost organizations in this arena, the American Society of Gravitational and Space Biology has a pivotal role in the future of space research and space exploration. As a Society we must strive to excel in three areas. First, we must support and encourage the best research in gravitational and space biology. Second, we must educate and train students and encourage young investigators. Third, we must effectively convey the message of the importance of gravitational and space biology research to elected officials, funding agencies.

Eberhard Horn is Professor for Neurobiology and Head of the Unit Gravitational Physiology at the University of Ulm, Germany. His research considers development, plasticity, and pathology of sensory and neuronal systems. He prefers the comparative approach and chooses suitable animal models to solve basic scientific questions. He was PI on STS-55, STS-84, and STS-90, Advisor for ISS Insect Habitat, and has published a Program for Gravitational Biology.
Vision statement: Gravitational Biology has become a reality in science. We can stabilize this position, but more important is to develop strategies to face offensively demands given by Science and Education. We have to show that Gravitational Biology is an investment in the future. No biological discipline offers a mandatory training in the "soft skills"–project management, team work, and international cooperation. Biochemistry, Biophysics, Microbiology, years ago only subdisciplines in Biology, have shown ways how to establish Gravitational Biology as an independent discipline at Universities. In collaboration with Universities, Politicians, Media, Space Agencies, and Space Industry, we can reach this goal for the Benefit of our Young Generation.

William Landis is Professor and Chair, Department of Biochemistry and Molecular Pathology, Northeastern Ohio Universities College of Medicine, Rootstown, Ohio. He was previously (1972-1989) in the Department of Orthopedic Surgery, Harvard Medical School and Children's Hospital, Boston. He holds a Ph.D. (biophysics) from MIT and has been an ASGSB member since 1990. He researches gravitational effects on bone development, is currently recipient of NASA and NIH grants, and has published over 90 peer-reviewed articles / book chapters.
Vision statement: I believe that the ASGSB should continue to promote the most outstanding research possible in all of its interest areas, using communication and education as its principle tools. This means the Society should take steps to encourage teachers at the high school and secondary levels to stimulate their students concerning gravity and space science, faculty at the college and university level to do the same, student scholars at the post-graduate level to pursue the profession, and individuals in private business and industry to lead advances in earth-based and space studies. Support from ASGSB in this manner will provide in turn an even greater awareness of our field of interest, a stimulation and motivation for individual and collaborative participation in scientific investigations, and an increasing opportunity for broadening the range of funding activities that can be embraced nationally.

Patrick H. Masson is an Associate Professor at the Laboratory of Genetics, University of Wisconsin–Madison. His research is focusing on the molecular genetic analysis of root growth behavior in *Arabidopsis thaliana*, with special emphasis on gravitropism. Current NASA and NSF–funded research is aimed at characterizing *Arabidopsis* genes that affect gravity signal transduction in the root cap, and of genes that affect the polar transport of auxin during graviresponse. Other research is

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Governing Board Candidates Present Their "Vision" for ASGSB

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also aimed at understanding the mechanisms that allow roots to develop complex (wavy) patterns of growth when exposed to a combination of gravity and touch stimuli.

Vision statement: Fast advancing disciplines such as genomics and proteomics add to an arsenal of genetic, biochemical, cell biological, physiological, and ecological approaches and allow the integrated analysis of biological processes with an efficiency never seen before. At the same time, rapid advances in communication systems allow better international cooperation and outreach. ASGSB has the opportunity to ensure that research in gravitational and space biology takes advantage of this integrated approach and leads the way in the development and utilization of novel technologies. This can be accomplished by promoting programs that would fund multidisciplinary research, risky and innovative projects, and student exchange between international laboratories, and by organizing joint meetings among international societies. ASGSB should also continue to advertise space biology at Washington, to the public, and to the scientific community.

Gloria Muday is an Associate Professor in the Biology Department at Wake Forest University. Her research is on the role of auxin transport in plant growth, development, and gravity response and includes both biochemical and physiological analyses of these processes. Her NASA-supported research focuses on the role of the actin cytoskeleton in development of auxin transport polarity and gravity induced growth. She is also a Principal Investigator in the NSCORT at North Carolina State University and was awarded the Thora Halstead Young Investigator Award by ASGSB in 1999.

Vision statement: The ASGSB is an organization that is ideally poised to facilitate communication between scientists, government, and the public regarding the importance of gravitational and space biology research. The outreach and education components of the Society's mission have grown tremendously in the past 10 years and these efforts need to be further supported as we reach times when the public and legislative branches of the government question the importance and rigor of research in this area. This is also a time when through our scientific meetings and publications we can really showcase the exciting discoveries and important results obtained by our members both to scientists and to those outside the scientific community. Finally, a unique and valuable relationship exists between ASGSB and NASA. The common interests and goals of this government agency and scientific society offer potential for exciting communication and valuable dialog about the future directions of gravitational and space biology research.

Myrtle Thierry-Palmer is Associate Professor of Biochemistry and Director of the Space Medicine and Life Sciences Research Center at Morehouse School of Medicine, Atlanta, GA. Her research specialties include metabolism and function of vitamins D and K, calcium metabolism, and salt-sensitivity. She is currently conducting research to determine whether salt-sensitivity, a genetic variation in the cardiovascular system, affects the physiological responses of space flight models.

Vision statement: The yearly meetings of the American Society of Gravitational and Space Biology provide a means of highlighting the status of gravitational and space biology research and of fostering opportunities for investigators to establish collaborative projects. The meetings should also include workshops on developing technologies that can be integrated into space biology research. There is a need to increase the participation of undergraduate and graduate students in gravitational and space biology research and in the ASGSB meetings. Efforts of the society should also be directed toward increasing the rather limited funding for gravitational and space biology research. This would involve continuing to educate congressional representatives and the public regarding the usefulness of the research. In its educational efforts with students and the public, ASGSB should emphasize the potential for gravitational and space biology research to also improve life on earth.

Richard Wassersug is Professor in the Department of Anatomy and Neurobiology, Dalhousie University, Halifax, Nova Scotia. He has published on experiments flown on MIR, a Biocosmos satellite, the Space Shuttle, and parabolic flights in Canada, the USA, and Japan. Dr. Wassersug has served on several NASA space biology working groups. Since 1989 he has been a member of the Canadian Space Agency's Life Sciences Advisory Panel. Dr. Wassersug joined the ASGSB in 1988 and has been a member of its Long Range Planning and Education Committees.

Vision statement: The ASGSB should promote research and education in all aspects of gravitational biology. In the short term, while the Space Station is being fabricated and access to space is limited, the ASGSB should encourage as much ground-based research as possible. As we move into the era of the International Space Station, it is fitting that the ASGSB become the premier international organization for the promotion of space biology. As a member of the ASGSB Governing Board, I would work toward increasing the growth of the ASGSB nationally and internationally, and advocate for increased access to space for all life scientists.

A Primer on Doing Research on the ISS

by Kathryn Clark*, Space Station Senior Scientist

Early in July I had the privilege of going to Khazakstan to watch the launch of the Russian "Zvezda" module. This cornerstone piece of the ISS has been blamed for the delay in construction for over two years. As my colleagues from the Space Station Utilization Advisory Subcommittee and I nervously watched the docking of this module to the existing orbiting hardware, I knew that it was up to NASA now to get the major pieces of the ISS into orbit and begin the long awaited utilization. What does this monumental achievement mean to you, the primary users of the International Space Station? It puts us 3 months away from a permanent crew, 6 months away from an active laboratory, and little more than a year away from a station with size and power that eclipse any previous spacecraft, and it will be open for business, dedicated primarily to research. As I retire from my position of Space Station Senior Scientist, I thought I'd leave you with my thoughts on how best to pursue research on the station. If I ever go back to the honest life of a researcher, this is how I would go about it.

Efficiency Through Collaboration

Efficiency is likely to be the buzzword for research on ISS. The most successful researchers will be those who have figured out how to make the greatest use of the limited resources, share data whenever possible, and cleverly design for additional information if the opportunity arises. The best way to increase efficiency is to share. Share data, crew time, or body parts whenever you can, with whomever you can.

Our peer review system is currently run though international channels. It would be most efficient to write proposals, design experiments, gather data, and write papers through the same international channels.

The first experiment I flew involved 11 PIs from 3 countries, literally sharing the body parts of 10 rats. It has been the most successful small payloads project to date.

I have been trying to push international collaboration since I came to NASA. It is incredibly inefficient to duplicate hardware in multiple labs simply because those labs were built by and are being used by different nations. By joining forces, combining resources, and delineating the on orbit labs by function, not nationality, we begin streamlining the space station.

Getting scientists to use the space station through collaborative efforts completes the process. This will, of course, wreak havoc with the bean counters who will insist that each country get only its proper percentage of the utilization of the ISS, determined by its contribution. As I see it, if the station adds up to greater than 100% because of "dual use," everyone wins.

With efficiency may come a bonus–time. For each experiment, there is a nominal sample size, necessary and sufficient for separating real differences from background noise. However, additional samples are almost always valuable, especially if the experiment can be varied just the slightest bit. I challenge the research community to find clever ways to pack extra samples, provide instruction for additional data collection, or tweak the experimental protocol to enhance the nominal experiment, just in case a crewmember is left with extra time.

How can I possibly expect extra crew time when we talk about how inundated the crew will be on orbit? We know from the Skylab days that as astronauts adjust to the space environment, their efficiency and productivity increase exponentially. Thus, I believe we may be (and rightly so) underestimating crew time for research. Also, when one experiment fails for any number of reasons, that block of crew time becomes unscheduled and can be filled with your experiment, if you are prepared.

Shannon Lucid ran into this situation on the MIR. She ended up with more free time than she wanted and would have been happy to fill it with additional data collection. And, quite frankly, even though we cannot schedule the

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* Dr. Clark is now the Chief Scientist for the Human Exploration and Development of Space Enterprise at NASA Headquarters. This job will primarily focus on strategic planning for education and outreach efforts with particular emphasis on affecting curriculum for K-12 schools and getting Universities involved with NASA.

A Primer on Doing Research on the ISS

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crew to work every day in space, many of the astronauts prefer to do some work "over the weekend," so to speak. Researchers should not expect extra samples to be processed, but if they are available, one can never tell.

Successful Crew Interactions

Speaking of the crew, please keep in mind that they are the technicians who will make the difference between success and failure for your experiment while it is in space. It behooves you to put some effort into their education.

One thing I discovered in my job is that designing your experiment to require crew interaction is a benefit to the researcher. I had originally thought that automation was the best way to design experiments because of the lack of crew time available on orbit. While this is a good idea for repeated or tedious tasks, an astronaut once informed me that the crew is much more likely to take an interest in something that requires a bit more interaction than pushing a button.

This could prove beneficial in the event that something goes wrong, or in the aforementioned situation of extra time. In fact, since many of the astronauts who will be on the ISS are scientists by training, they will likely take some personal interest in your work, if you engage them.

The "Brief"

The first time an astronaut will see your experiment is usually through a one-page description put into their task book along with *MANY* other experiments, documents, and required jobs. If you send NASA a lengthy description containing every detail of your history, your work, and the minutia of instructions, some poor sap in the office will cut it down to a one pager for you. Do yourself a favor. Write the description the way you would want it to be seen by an intelligent person who does not necessarily work in the field.

First appearances are important. Now would be a good time to pique her interest. The same thought should go into an oral presentation given to an ISS crew, if you get the opportunity. Many scientists have had the opportunity to brief the crew on his or her experiment. The operative word here is "brief." A concise description of the experiment and the benefits of doing it are sufficient background. I had one astronaut tell me that while he was highly interested in several of the experiments he was assigned to on orbit, he would not have time to delve into the details prior to his flight.

A short, enthusiastic description of the benefits of the work will go a long way toward getting your experiments performed with maximal return.

Be Concise and Specific

This brings me to another important topic in the way of crew interaction and efficiency; the written description of the experimental protocol.

Concise and specific are the words to live by. A rambling description that must be read several times is equally as bad as a vague description that leaves portions open to interpretation. Again, remember, if you write this as an essay, someone in a very dark office buried beneath Johnson Space Center will turn your document into a check list, not necessarily the one you want, and then may translate this abridged version of your experiment into Russian. And it might get translated back to English via Japanese before the crewmember on board gets to read it. By the way, the first language of said crewmember may not be English. Do you get my drift?

The most efficient way to send a protocol to a technician is for you to write it precisely, use the protocol yourself for a dry run, and insure clarity of writing. This is actually another advantage of having an international team designing the experiment and the protocols. If the international team on the ground understands the description, there is a good chance that the international team on orbit will as well.

Another important variable in this issue is timing. It could be several months between your initial introduction of the experiment to the crew, along with training, and the actual start of the experiment in space. So, your protocols may need to serve as little refresher courses as well.

There is some push to create CDs that would provide a high level description of an experiment, but allow for in depth knowledge of the experiment, background, and design for those who had both time and interest. If this system of training becomes available, I would encourage you to participate fully. As with all of these exercises, the benefit is entirely to the researcher.

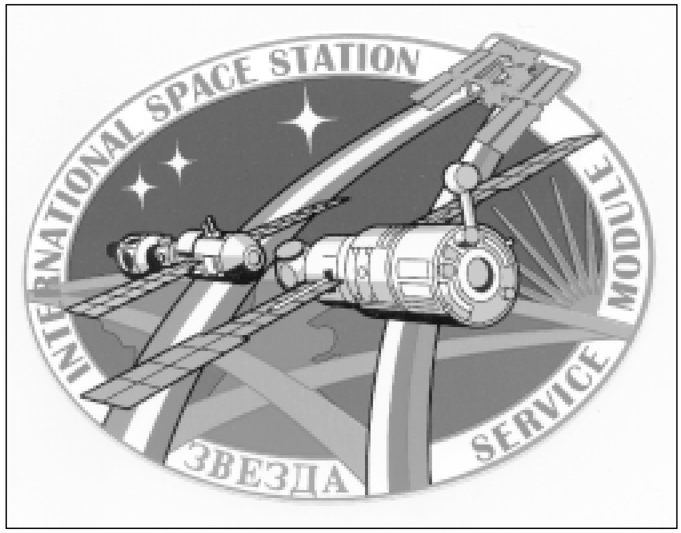
Teamwork and Honesty

A small aside on the subject of crew interaction. Be nice and be honest. These traits are also helpful to any scientist who wants to be successful in space research, especially for the long haul.

While the astronauts are professionals and will complete your experiment to the best of their ability, on orbit, when resources are tight, everything will be subject to prioritization by the crew. A scientist who is nasty and condescending to the crew might just find his experiment sliding rapidly to the end of the list. And there is simply no excuse to be a jerk to the astronauts, and certainly no reason to be condescending. No matter how impressive your CV is, the astronaut's is better. Get over it. Teamwork is the key ingredient for success on the ISS so play nice.

Honesty is another important characteristic when dealing with crews. I heard of a researcher who neglected to tell the crew that they would have to give up their own personal storage space to carry experimental samples to orbit. Had the researcher been honest up front about the lack of space for samples, the astronauts might have been willing to do it because the experiment was interesting and useful science. However, the scientist tried to sneak it by them and in the end, lost out on her experiment. That same researcher will likely have a tough time getting any experiment through the astronauts in the future, now that trust has been lost.

If you make a good case to the crew, they are willing to give up a lot in the name of research, but be above board and make the case up front.



Redundancy

There is one exception to my plea for efficiency. That is to be sure to build some redundancy into your experimental hardware. I heard of an experiment that failed entirely because a fuse blew on flight day 1 and the researchers had neglected to send up a replacement for this unique fuse.

If your experiment fits into standard equipment on the ISS, NASA will be providing extra pieces like that, but it doesn't hurt to check. If you have experiment-unique hardware, the need increases. Of course, if you let your experiment fail, that will leave crew time available to enhance another researcher's experiments, if she was clever enough to send up extra work.

Summing It Up

For all of its splendor, the ISS will always be a limited and highly specialized resource. Upmass, downmass, size, power, data links, images, crew time, air flow, water flow, cooling, heating–these will all have a finite limit.

You will be sharing the ISS with many researchers in multiple fields, taxing different systems at different times. Managing the research on the ISS will be more difficult than its construction.

You can make a difference by designing with efficiency, explaining the experiment clearly, and by sharing the resources so that we get the biggest bang for our buck, or ruble, euro, or yen.

by Kieran Smart
Flight Surgeon for SPACEHAB Human Engineering Flight Projects Division, Johnson Space Center

Space life scientists throughout the world eagerly await the start of science operations at the ISS that will begin with the 5A.1 flight tentatively scheduled for February 2001. This flight will begin to outfit the U.S. Lab, which will be delivered on flight 5A, and (with the Russian FGB and SM) will provide the initial research capability. The foremost concerns for ISS crewmembers operating these payloads will be the physical and psychological challenges of the space flight environment and the technological support required to live there. This operational environment places great demands on individual crewmembers. At the same time, the dangers and complexities of living and working on long-duration flights make crew cooperation and cohesion necessary for mission success. To date we have mainly focused on the physiological aspects of space flight, particularly the consequences of microgravity on the various body systems. A wider multi-disciplinary approach to crew support will become increasingly important in ensuring ISS mission success.

Microgravity causes a number of important physiological changes to the cardiovascular, respiratory, musculoskeletal, endocrine, and neurological systems. Some of these changes will affect performance in relation to the operation of payloads. For example, the significant changes that occur in the accuracy of psychomotor performance combine with the postural changes that occur, such as the adoption of a fetal position, to result in a tendency to overshoot until adaptation occurs. This decrease in dexterity can pose potential problems for the manipulation of control panels and displays, payloads, and mechanical systems. In addition, the problem of space sickness poses an additional immediate threat to performance in space, with the result that EVAs are not planned in the first few days of a mission.

Interestingly, the first time an ISS crewmember will see a complete station inside and out will be in space as she or he approaches ISS in the Shuttle. The ground-based training models will consist only of four or five (at most) joined elements of the station. Therefore consideration must be given to the effects of spatial disorientation and situational awareness. These effects are eventually overcome as the crewmembers adapt to their environment, although disorientation and 3D mental modeling of the complete station remain problematic. This problem is most significant during potential emergencies; however, even in day to day activities new crewmembers may initially have trouble finding their way around the station, especially at assembly complete.

With the experience of Russian, ESA, and U.S. crewmembers on Mir, the importance of the psychological element in long duration missions is increasingly recognised. The effects of confinement, isolation, environmental challenges, and the consequent group dynamics, have been well documented in analogue situations such as the Antarctic and in submarines. Additional psychological stressors come from poor and limited communications, on-orbit equipment failures, poor living conditions, high and low workloads, and are compounded by crew interpersonal tension, multicultural issues, and the lack of privacy. In space, the isolation can lead to sleep disturbance, headaches, irritability, anxiety, depression, boredom, restlessness, anger, homesickness, and loneliness. All of these clearly can have a significant impact on the productivity and performance of the crew carrying out your science.

A significant problem in the early stages of ISS operations will be stowage. Video footage taken on the last two missions clearly shows the extent of the problem, which will affect both the habitable space and access for the crew, particularly in the early stages of assembly. Until assembly is complete, it is likely that equipment will be stowed in the open areas such as the nodes and the module passageways. As was seen on Mir, this caused problems during daily activities. Items became lost, and impaired access to panels and experiments caused significant delays. It was not unusual for crewmembers to spend many hours simply moving stowed equipment to get access to payloads.

In earlier missions a variety of unscheduled, on-orbit factors have at times challenged the ability of crews to complete tasks according to scheduled timelines. These factors have included high workloads, equipment difficulties, unscheduled maintenance, extravehicular activities (EVAs), ground communications, retrieval of lost items, stowage and trash management. The time estimated to carry out tasks and experiments has on occasion been underestimated; therefore, organizing the timeline is a performance challenge in its own right. In addition, crewmembers have expressed concerns on the potential impact of the 0-*g* environment on each task performed, reinforcing the concept that there are positive and negative aspects to training in 1-*g* for the 0-*g* environment. For example, crewmembers noted that they could take advantage of weightlessness when handling large tasks, but found difficulty in handling small objects, especially multiple items.

Stowage problems were significant on Mir, and will continue to be an important consideration during ISS utilization.

Workload has to be delicately balanced between too much and too little activity, with the most complex tasks being assigned early in a given work period to minimize mistakes. There appears to be a general trend toward reduced performance of those tasks that require either sustained concentration or systematic shifts in attention. This strongly suggests that the more demanding the schedule, the more severe the performance impairment both during and after the tasks. It seems clear that a high work/rest ratio is not likely to be practical for long-duration missions.

Monotony can also occur when tasks require little cognitive processing or attention, are highly repetitive, are not complex, and/or have been extensively over learned, with the result that attention tends to drift, signals are missed, and performance is lethargic. The aim is to have a balance of activity and to determine what specific work/rest schedules would be best over extended durations.

There is an obvious need to explore how mission activities might be integrated to minimise fatigue, both with respect to the absolute amount of work required and to the sequential processing of tasks involving various levels of complexity and effort. A tired crew is not only more likely to have a reduced level of performance, but will also make more mistakes. Scientists need to consider such difficulties when time-lining their experiments by determining if the procedure requires more time/resource allocation than scheduled.

Disruption of the normal circadian rhythms surrounding sleeping, eating, blood pressure, pulse, respiration, urine volume, and body temperature results in physical symptoms that include insomnia, anorexia, malaise, and nervousness. Because circadian rhythms have a range of implications for performance, methods of retraining rhythms to the most advantageous sleep-wake cycles, such as directing the normal rhythms, use of lighting, social cues, leisure activities, and privacy are important. For example, artificial lighting and social cues revolving around daily meals, work/rest schedules, and evening leisure activities serve as strong cues to periodicity and are important for regulating work related performance. NASA Senior Astronaut and Flight Surgeon, Story Musgrave, has reported that time has little meaning in space flight except as it relates to elapsed time or work schedules. These findings have important implications for operators in space, particularly for the manner in which activities are planned.

As space crews become increasingly heterogeneous and routinely multicultural, there is a need to understand the interrelated physiological and psychological factors that lead to decreased performance, health, and morale. The ISS at assembly complete will have as many as seven mixed sex permanent crewmembers from several countries living and working in a closed, confined environment. The great human challenge of the ISS program is to enable the crew to maintain a high level of performance to carry out the science activities we all eagerly await. Accomplishing this goal will require the integration of human factors, psychology, human engineering, flight medicine, payloads, and the scientific community in all aspects of mission planning, vehicle design, crew training, and support.

MEMBER SPOTLIGHT: Space Hardware Optimization Technology, Inc.

By Paul Todd and Rich Boling

Scientists and engineers at Space Hardware Optimization Technology, Inc. (SHOT), held their breath July 12 while half a world away on the steppes of Kazakhstan, the Russian-built Zvezda command and control module of the International Space Station (ISS) lifted off from launch pad 23 at the Baikonur Cosmodrome.

Along with the entire international space science community, they breathed a collective sigh of relief when on July 25 Zvezda successfully docked with the existing components of the station, which have been on-orbit since 1998. The employees at SHOT were justifiably ebullient–the company is currently designing and developing three payloads that are manifested to fly on early missions to ISS.

Flight experience

Headquartered in Greenville, Indiana, SHOT is an applied-technology company that provides engineering services and equipment to customers performing research both in space and in their ground-based laboratories. Most of SHOT's current contracts are with the National Aeronautics and Space Administration (NASA). Hardware developed by the company has been launched on three sub-orbital rocket flights and on six space shuttle missions. When legendary astronaut John Glenn returned to space recently he was assigned to operate SHOT's scientific research hardware. He mentions this by name in his recent book *John Glenn: A Memoir*. As a result of its flight experiment success, the company has earned a reputation as an organization that has consistently developed and delivered high quality hardware on-time and on-budget.

SHOT's staff has been selected to blend highly experienced individuals with space experience with individuals that have specialized innovative and design skills. This mix and the success that SHOT is enjoying have created several employment opportunities for early-career individuals interested in working with emerging technologies in an environment of discovery and innovation.

From a payload integration perspective, SHOT also has experience with systems safety engineering (for manned missions), flight hardware verification testing, and integration documentation preparation and management. From a flight experiment perspective, the company has experience with mission planning and management, mission operations training, and mission operations.

Hardware Innovations

Avian Program

SHOT's avian development program has been going strong since 1983 when the company's co-founders, Mark Deuser and John Vellinger, began developing flight hardware for the first U.S. avian microgravity experiment. That first generation avian flight hardware was developed for two shuttle middeck flight experiments, STS-51L and STS-29. Experiment results helped establish a high priority for avian microgravity research within NASA, and the hardware performance established Deuser and Vellinger as the leading experts in avian flight hardware development. A flight-certified second-generation unit, the Avian Development Facility, is currently being assembled and is manifested to fly in late 2001. An Avian Hatchling Habitat also is nearing the final stages of development.

Avian Development Facility.

Separations Technology

Aqueous Two-Phase Partitioning (ATPP) is a unique separation technique that allows purification and classification of biological materials. SHOT has employed the ATPP process in separation equipment developed for both space and ground applications. Initial equipment development and research focused on the ORganic SEParation (ORSEP) space flight experiments that were performed on suborbital rockets (Consort 5 and 6) and the shuttle (SPACEHAB 1 and 2). ADvanced SEParations (ADSEP) technology was developed as the next generation of ORSEP. The initial step in marketing space processing services came in 1998 when the Canadian Space Agency (CSA) became the first paying customer to take advantage of the ADSEP hardware. Besides the CSA, NASA also used the unit to conduct an extremely successful cache of experiments (microencapsulation, crystal growth) to demonstrate its full capability. ADSEP achieved these milestones when it was flown on STS-95. ADSEP microgravity research is expected to continue on the International Space Station (ISS). It is included on the traffic model for ISS Increment 12A.1.

Capitalizing on the multistage technology developed for ADSEP, SHOT devised a method for quantitatively separating cells, proteins, or other particles, using magnetic fields to drive the separation. MAGSEP is a multistage device in which cells labeled with varying numbers of paramagnetic beads are separated quantitatively, stepwise on the basis of the extent of labeling by using magnetic fields of increasing strength. MAGSEP enhances product recovery by collecting fractions automatically and provides differential separation where only binary separations were previously possible.

SHOT has devised a purification method that combines free electrophoresis and multistage extraction in an instrument, ELECSEP, capable of separating living cells, particles and proteins in useful quantities and at high concentrations. The isothermal process depends on the electrophoretic mobility of separands, and is gravitationally stabilized so that it functions in laboratories on earth and in space.

Senator John Glenn with ADSEP Flight Hardware on STS-95.

Thermal Carriers

The success of biotechnology research on the ISS will depend extensively on reliable, thermally controlled, flight hardware. In response to this requirement, SHOT developed the Thermally Controlled Facility (TCF). The TCF is a reusable, reconfigurable, middeck locker-sized unit, capable of providing a thermally conditioned environment for biological samples being processed on, stored on, and / or transported to and from ISS. SHOT's TCF unit features advanced thermal technologies associated with high-efficiency insulation, precision temperature controlling systems, passive thermal storage, and environmentally controlled transportation.

BIOFAC is a carrier with flight-proven technology that includes: on-orbit sample changeout by flight crew; three independently controlled processing modules; tele-robotic manipulation of samples; and tele-operational control of experiments from the POCC and the capability to perform cell culturing experiments. BIOFAC housed the ADSEP experiments on STS-77 and STS-95.

In December 1998, SHOT completed a project with NASA's Marshall Space Flight Center and the University of Alabama-Birmingham to develop an advanced refrigerator / incubator suitable as a replacement for existing thermal carrier equipment, like the Refrigerated Incubator Module (RIM) and its commercial version (CRIM). SHOT developed a protoflight version of its thermal carrier, appropriately named CLIMATE, which addresses the needs of biotechnology researchers who are conducting investigations in a controlled thermal environment on the space shuttle, and researchers envisioning investigations on ISS.

CLIMATE is capable of maintaining an isothermal environment in the experiment control volume and commanding / controlling the temperature, either in a steady state, or via a programmable temperature profile. It is also capable of accommodating experiments requiring temperature gradients via conduction or convection thermal control. CLIMATE is fully compatible with the space shuttle's middeck and ISS Express Rack accommodations and is capable of supporting existing experiments with minimal modifications to the experiment interface hardware. To facilitate ground and in-flight operational changes and reconfiguration, it incorporates a smart system, built around an onboard microprocessor that is easy to program, control, and operate. CLIMATE features full telescience capability by providing downlink, as well as real time uplink of operational commands. As a processing unit, the reusable CLIMATE provides front loading access to biosamples, permitting on-orbit sample change-out and manipulation. As a sample storage and transporter device, it offers the capability to transport biosamples from Earth to ISS and then to return processed biosamples back to Earth. CLIMATE makes efficient use of the minimum limited resources, including power, weight, and volume by using advanced heat exchanger assemblies, user friendly data and control software, energy efficient power converters, high performance insulation, and ultra-lightweight housing materials.

Cell Culture

(Continued on page 14)

MEMBER SPOTLIGHT: SHOT, Inc.

(Continued from page 13)

SHOT's CELLCULT cassette was developed for the commercial Biodyn project at the University of Alabama in Huntsville and was operated in the BIOFAC thermal carrier on STS-95. It consists of a 50-ml bioreactor, which can be rotated with fresh-medium perfusion, external oxygenation loop, and on-demand collection of up to six samples of cell-suspension or clear supernatant. All functions are teleoperable and under computer control in one third of SHOT's BIOFAC carrier.

Advanced Animal Habitat.

Advanced Animal Habitat-Centrifuge

The Space Station Biological Research Program, which is being managed by NASA's Ames Research Center (ARC), envisions a cache of six habitats, each having access to a large diameter centrifuge, to fulfill the non-human life sciences research requirements. The Advanced Animal Habitat (AAH-C) for the ISS Centrifuge Module will play a vital role on the ISS by facilitating studies that utilize rats and mice.

SHOT and STAR Enterprises, Inc. (Bloomington, Ind.), teamed together in 1996 to propose an effective approach to developing the AAH-C, and subsequently were awarded a contract from NASA ARC in August 1998 to begin that work. STAR-SHOT proposed, and NASA accepted, a phased evolutionary approach to the project, consisting of three different phases (Parts 1-3) of development for the habitat design, fabrication, testing, and implementation. AAH-C Part 1 is a habitat system that is suitable for group-housed adult rats, as well as an insert that is modified appropriately for group-housed adult mice.

Eventually, with the completion of Parts 2 and 3, the AAH-C will accommodate individually housed adult rats, mice at all phases of their life cycle, and it will be equipped with a biotelemetry system. When all three parts of the program are completed around 2007, STAR-SHOT expects to have developed, fabricated, and verified 10 flight units, as well as multiple qualification, training, science-evaluation, and ground-control units.

Spaceship Earth

Research laboratories in space have the potential to help solve many terrestrial challenges. Over the next ten years, biotechnology and the health care industry are expected to benefit significantly from microgravity research. As the demand for customized biomedical research equipment increases, the market for SHOT's innovations continues to grow. Because SHOT has designed and built flight hardware for NASA, it is accustomed to working with extremely difficult constraints. Limited size, power, weight, and numerous other requirements have demanded that its engineers be creative and innovative in their design concepts. This engineering philosophy lends itself to developing hardware that is well-suited for research in extreme environmental conditions on Earth. Also, equipment that is more efficient in terms of power usage, volume, weight, and thermal control is always desirable in the terrestrially based biomedical and biotechnology commercial markets. In fact SHOT is already moving toward large-scale production of a bench-top ADSEP unit.

With contracts to develop flight hardware extending well into the future, SHOT's expertise in developing equipment for biological research and the integration of such payloads will continue to increase. For more information about SHOT's hardware and services, or to inquire about specific employment opportunities, visit the company's Web site at http://www.SHOT.com or call (812) 923-9591.

Formerly a chemical engineering research professor and Associate Director of the BioServe Space Technologies Center at the University of Colorado, Dr. Paul Todd is currently the manager of the Bioprocessing Program at Space Hardware Optimization Technology, Inc. (SHOT). Rich Boling is the communications manager at SHOT.

SHOT is a Corporate Member and sponsor of ASGSB.

A Visit to Ukraine for a Follow-up Program to the Collaborative Ukrainian Experiment

From May 29 through June 8, 2000, Kennedy Space Center representatives Peter Chetirkin and Tom Dreschel returned to Kiev, Ukraine to continue collaborative educational programs initiated during the Collaborative Ukrainian Experiment (CUE) in 1997. The CUE project was a series of plant experiments performed by Ukrainian Cosmonaut Leonid Kadenyuk on Mission STS-87. Principal Investigators from the U.S. and Ukraine designed and implemented experiments with *Brassica rapa* and other plant species.

A significant educational component was developed and carried out by the Wisconsin Fast Plants program at the University of Wisconsin-Madison, under the direction of Professor Paul Williams. On the Ukraine side, Dr. Volodimir Nazarenko, who is the vice president of the Ukraine Junior Academy of Sciences, implemented the education program. Kennedy Space Center provided support both for the science and the education program. Since then, collaboration has continued with the education program in the development of "Farming in Space" by the Wisconsin Fast Plants program, presented in both the U.S. and Ukraine. In addition, the SEEDS II project and a water-quality project (supported by Brevard Community College) have been introduced and continue to be embraced in Ukraine.

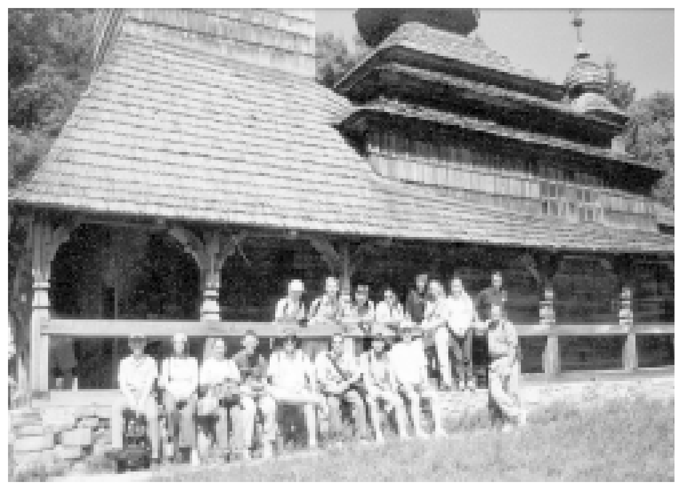
The purpose of this trip was to participate in a teacher symposium and to initiate a student-exchange program. Eight students from Lake Brantley High School, Florida, with a teacher and parent chaperone accompanied Peter and Tom. In addition, a reporter from an Orlando television station and her cameraman went along to cover the student experiences. Dr. Nazarenko and his colleagues with the Junior Academy of Sciences again hosted us. The Lake Brantley contingent has formed a follow-up program to the CUE-TSIPS, which they call CUE-STEPS (CUE-Science, and Technology Exchange Program for Students). They are currently holding fund-raising events to help defer the cost for students from Ukraine to visit Lake Brantley students next spring.

Day One: Arrival and Traditional Ukraine Greetings

At the airport in Kiev, we were greeted by youth in traditional Ukraine costume bringing bread and salt, a traditional greeting, and the students first began to interact with students in Ukraine. During the visit, the CUE-STEPS group visited the Kiev Palace of Children and Youth and joined in discussions and tours with their counterparts in Ukraine. On another occasion, the group visited an orphanage, Internat, which is really a second grade through high school campus. The U.S. students discussed their schooling with the older students (teens) there and found that the schooling is very similar. The school prepares them either for college or a trade. We also visited a planetarium in Kiev for a tour and a musical star show.

Day Two: Zhytomyr and the Ecological Center

We visited the town of Zhytomyr, which is the birthplace of S.P. Korolyov, the chief rocket designer of the former Soviet Union. While there we visited the Korolyov birthplace and home and a space museum dedicated to him. Inside the museum are Soviet space capsules and equipment, historic information, and an exhibit on the STS-86 mission with pictures from the CUE mission. While there, we also visited a natural history museum and the student Ecological Center. The natural history museum has a very moving Chernobyl exhibit. At the Ecological Center, we were again welcomed with bread and salt. The reception our group received at the Ecological Center was outstanding. We toured the classrooms, where students showed us their continuing research with the CUE-TSIPS project and their current research with the space tomato seeds from SEEDS II. They then fed us very well and we even ate raw Chinese quail eggs.



Tom Dreschel (right) and students at the Ukraine architectural museum.

(Continued on page 16)

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Day Three: Kiev

We visited with the Vice-Mayor of Kiev and the city's Education Director. Later we met at a school called a "gymnasium" and were welcomed with bread and salt. Nadia Adamchuk, a Ukrainian Cosmonaut was there to visit with us at the school. The young children of the gymnasium put on several dancing skits and we toured the school. We ate lunch of vereneke, ham, and bread. The U.S. students joined with the Ukrainian students and did a few dances. Later we moved outside, had a nice parting ceremony, but had a difficult time leaving.

Day Four: Field Trips

On day four, a boat trip on the Nieper River took us to a camping spot, where we went on field trips with local naturalists, and the students tested the water using portable water test kits. Then we had borscht and other local cuisine for lunch. There were about fifty students and teachers on the trip.

Days Five and Six: Architectural Museum and St. Vladimir's Cathedral

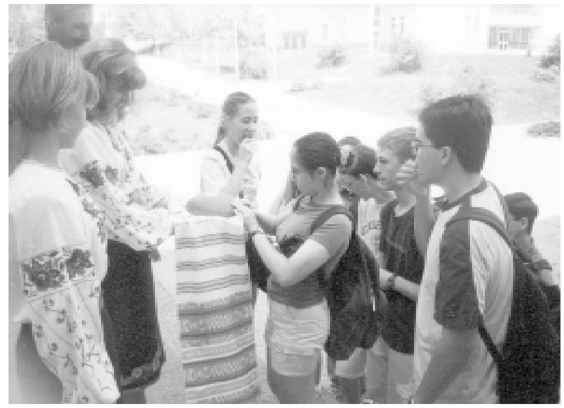
The outdoor Architectural Museum that we visited had buildings representing the various regions of Ukraine. We spent the whole day walking among the interesting constructions. The next day, being Sunday, we attended mass at St. Vladimir's Cathedral and later went to a botanical garden and an open-air market so that the students could purchase souvenirs. On another occasion we took in a ballet.

Day Seven: President Clinton in the Ukraine

On June 5th, we visited the Kiev student Ecological Center for a teacher workshop. In the afternoon we went to the square at St. Michael's and stood for four hours in the blazing sun and crowd to see President Clinton. He made a nice speech about how Ukraine should keep fighting to support democratic government, and how the U.S. will continue to support them in space, science, technology, and government.

Day Eight: Schools, World War II Museum, and Hospitality

The next day we went to another school in the Kiev region, Vysgorov, and the students and teachers met us at the door with salt and bread, and a band played "The Stars and Stripes Forever" as we came in. We had meetings with discussions, songs, and dancing. Later we left to visit a cathedral under reconstruction since being destroyed by the Nazis. Then we visited a museum on the WW II battle for Kiev. It was a very moving site and the students got into trenches that were used during the battle. Upon returning to Kiev, we stopped at the Monastery of Caves and climbed the bell tower (higher than the Tower of Pisa).



A traditional Ukraine welcome at the school in Vysgorod.

Day Nine: Press Conference

This day, we visited another school in Kiev, a school of math and business. Again there was singing and dancing, discussions on ecology and tours. Then we went to a press conference held for us and hosted by Monsanto. National Space Agency of Ukraine Deputy Administrator, Dr. Edvard Kuznetsov, Cosmonauts Leonid Kadenyuk and Dr. Nadia Adamchuk, and a number of the CUE researchers including Drs. Elisabeth Kordyum, Antonina Popova, and Svetlana Kochube were there as well as Dr. Nazarenko and teachers and students. The press conference appeared on television in Kiev that evening. Later we visited with Dan Thompson at the USAID about possible collaborative programs.

Day Ten: Goodbyes

On our final day, we visited the U.S. Embassy in Kiev to meet with Embassy Officer Nancy Heingarter, Deputy Chief David Hess, and Ambassador Steven Pfeifer. After one final trip to the Hotel Ukraine, we packed our bags, said our final good-byes to our Ukraine colleagues, and left for home.

We have now been to Kiev each year since the CUE program began, and each visit is a more enriching experience. We have assisted Dr. Nazarenko and the Junior Academy of Sciences in receiving funding from both private sources and government to continue his programs. We continue this collaboration with hopes to continue into the future and to expand it to other countries; particularly International Space Station partners. We also believe that this trip may be the first step in a series of student and teacher exchanges between the U.S. and Ukraine.

Tom Dreschel and Peter Chetirkin
Kennedy Space Center

NASA Restructures OLMSA to Create New Enterprise Focusing on Biology

NASA announced September 29 a restructuring of the Office of Life and Microgravity Sciences and Applications (OLSMA) to strengthen the agency's ability to meet the challenges brought about by the growth in areas such as molecular biology, nanotechnology, information technology and genomics. Under the new plan, OLMSA will be renamed the Office of Biological and Physical Research (BPR) and enhanced to form a separate enterprise focusing on scientific research. Previously, OLMSA was a part of the Human Exploration and Development of Space Enterprise (HEDS). The new BPR office will work closely with HEDS to facilitate long-term exploration of space.

The reorganization is consistent with NASA Administrator Daniel S. Goldin's vision to create an interdisciplinary research program focused on biology, bringing together physics, chemistry, biology and engineering. "Through this new enterprise, the best and brightest from across the sciences and across the country, can focus their talents on meeting the challenges NASA faces in our future missions," said Goldin.

NASA Chief Scientist Dr. Kathie L. Olsen will be acting Associate Administrator for the new enterprise, and will return to her position as Chief Scientist once a permanent Associate Administrator is named. Dr. Julie Swain will serve as acting Deputy Associate Administrator.

BPR will include a wide spectrum of scientific research, including basic, applied, biological, physical, chemical, and biomedical. BPR will be made up of five divisions:

- The Physical Sciences division will be structured to promote cross-disciplinary physical, chemical, biological and theoretical research.
- Fundamental Space Biology will be established at the division level to apply the revolutionary changes in molecular biology and genetics to a space-based environment.
- Biomedical and Human Support Research will also be established at the division level and will integrate fundamental and clinical research to prioritize crew health, medical and environmental technology issues. It will focus research on critical crew health, safety and performance issues.
- The Division of Research Integration will focus on cross- discipline research and resource integration within BPR and across NASA.
- The Division of Policy and Program Integration will not be changed under the reorganization.

Goldin noted that advances in biological sciences are opening new opportunities for the space program. Just recently, NASA entered into an agreement with the National Cancer Institute to work on nanotechnologies with a dual purpose—to develop revolutionary technologies for early detection of cancer in patients here on Earth and early detection of illness in astronauts up in space.

"By combining NCI's expertise in biochemistry, molecular and cellular biology and clinical medicine with NASA's expertise in physical micro-systems and biotechnology, we can develop the fundamentals for an entirely new technology discipline," said Goldin.

The new enterprise will create an infrastructure that integrates research and technology, broadens NASA's peer-reviewed research programs to strengthen ties with universities, and provides answers to questions fundamental for the future.

NASA Institute for Advanced Concepts Call for Proposals and Workshop for Innovative Improvements in Aeronautics and Space

The NASA Institute for Advanced Concepts (NIAC) has released, in September, NIAC Phase I Call for Proposals, CP00-02, as a continuation of the process to identify and nurture revolutionary advanced concepts that may have a significant impact on the future of aeronautics and space. ***Proposals are due February 18, 2001.***

Check the NIAC website periodically to receive any updates or additional guidance regarding CP00-02, <http://www.niac.usra.edu>.

NIAC is sponsoring a workshop, *Innovation at the Interface of Scientific Disciplines: Redefining the Possible in Aeronautics and Space*, in Atlanta at the Georgia Center for Advanced Telecommunications Technology (GCATT) in Atlanta, November 7-8, 2000.

The purpose of the workshop is to inspire a new and innovative class of advanced architectures and systems for visionary, revolutionary improvements of fields of aeronautics and space. The workshop may provide additional opportunities for you to formulate or refine your innovative ideas through workshop sessions and interaction with your colleagues. The atmosphere of all sessions will be informal to promote an unbiased forum for interchange of ideas, concepts, perspectives of emerging technologies, challenges of aerospace endeavors and visions of emerging possibilities.

Robert A. Cassanova, Ph.D.
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From Gravitational to Space Biology in Bonn

by Andreas Sievers
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1. Introduction

Imagine: If a photobiologist could not switch off light in order to study dark controls, our knowledge of light signal transduction in eyes, or photomorphogenesis in plants, as well as photosynthesis would be utterly incomplete. What is true for photobiology is also true for gravitational biology. We need controls. However, where—with respect to gravity (and other stimuli)—do unstimulated roots exist? Vertically growing roots often used as controls are permanently stimulated by gravity; tilting roots is nothing more than a change from static to dynamic gravistimulation (Sievers et al. 1991). Only the stimulus-free microgravity environment (approx. 10^{-4} *g*)—as the International Space Station will offer in the near future—can routinely produce unstimulated roots (Sievers 1999; exception: cf. Section 2).

A short look at three papers may illustrate the problem. (i) By means of energy-filtering transmission-electron microscopy, Marion Busch detected more calcium signals in membranes of the gravity-sensing cells of cress root (statocytes) than in non-excitable cell types of the root (Busch et al. 1993); an especially clear difference exists between the plasma membranes of neighbouring statocytes and meristematic cells. Is that a sign for a role of calcium in the main function of statocytes, namely transduction of the gravity stimulus? "The evidence ....is ....substantial but still circumstantial" (Sinclair and Trewavas 1997); a control is missing. (ii) Legué et al. (1997) found that the cytoplasmic [Ca^{+2}] in statocytes does not appear to be different from that in other root cells and is not changed by gravistimulation. Did the authors compare stimulated statocytes with the optimal controls, namely absolutely non-stimulated cells? No. (iii) Differential activity of phosphatidyl-inositol-4-phosphate-5-kinase was found in the lower and upper side of grass pulvini after gravistimulation, indicating the involvement of inositol-4,5-bisphosphate, a second messenger known to activate calcium release from internal stores, in early gravitropic events (Perera et al. 1999). It may be concluded that calcium and phosphoinosites act as second messengers in the signal transduction pathway. In this special case nature solved the problem of controls: it is well known that fully differentiated and vertically oriented grass pulvini do not grow. It seems as if they sense gravity during dynamic gravistimulation; then they start growing by differential flank growth, which means that cells from the lower side begin to grow (cf. Sievers and Hejnowicz 1992). Cells of vertical grass pulvini are natural controls.

Another problem that exists on Earth is the fact that experiments at < 1*g* are impossible. This may be solved in microgravity where stimuli between 1 *g* and 10^{-4} *g* can be generated by a centrifuge onboard. Thanks to political decisions in and between different nations, since 1967—when the first biosatellite landed with excellent scientific results—facilities like drop towers, sounding rockets, satellites, and spacelabs are being frequently used by the scientific community. With regard to the limiting factors like high costs, scarcity, and time consumption, all space experiments need to be most thoroughly prepared on the ground; especially the use of the right types of clinostats for the simulation of weightlessness is a necessary precondition for experiments under microgravity conditions.

2. Simulation of weightlessness

It is well known that static gravistimulation is switched off both by clinorotation and microgravity. Dynamic stimulation is switched off by microgravity but occurs inevitably during clinorotation and may be perceived by cells if the rotation is not fast enough (Sievers and Hejnowicz 1992). Only the fast-rotating horizontal axis of a clinostat (50-120 rpm; in comparison with the slow-rotating axis: 0.25-4 rpm), on which the radial distance of cells from the axis is small enough (< 0.5 mm) to keep the centrifugal force low, can effectively compensate gravity (for review Briegleb 1992). How negative the effect of the permanent dynamic stimulation on the slow-rotating clinostat on cells and organs is, was demonstrated by Hensel and Sievers (1980). We discovered self-destruction of statocytes (cf. Staehelin et al. 2000) and weaker graviresponses after 20 h of clinorotation of roots (which were germinated without rotation) and interpreted this damage as an effect of chronic overstimulation.

Before the Bonn group had access to a real microgravity environment, we studied the development of cress roots and their statocytes on the fast-rotating clinostat (Sobick and Sievers 1979). These experiments provided an excellent base for the later studies in orbit. Wolfgang Briegleb (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Bonn, now Deutsches Zentrum für Luft- und Raumfahrt DLR, Köln) developed and constructed the prototype of the fast-rotating clinostat and Volker Sobick used it. With respect to a 1-d-old cress root this clinostat can indeed compensate gravity because the diameter of the root is < 1 mm.

Volker conducted two groups of experiments. (i) Seeds were oriented with their longitudinal axis exactly in the rotational axis of the clinostat; this is optimal for the simulation of weightlessness. (ii) The distance between the rotational axis and the seed axes was increased stepwise; thereby exposing the radicles in the seeds to centrifugal accelerations from (minimal) $4.3 \times 10^{-3} g$ to (maximal) $1.7 \times 10^{-2} g$ and the growing root tips (at the end of the experiments) from (minimal) $10^{-2}\,g$ to (maximal) $2.2 \times 10^{-2}\,g$. The experiments ran for 16 h at 55 rpm. The result of (i) was most surprising: in simulated weightlessness, the roots did not develop straight along the rotational axis, as was expected. Instead, they continued growing in the direction which is shown by the tip of the curved radicle within the seed coat (Fig. 1). We had discovered an autonomous development of roots in an environment with constant outer conditions (Pfeffer 1904): the stimulus-free environment (cf. below and Section 3)! The results of (ii) clearly showed: with increasing distance between the rotational axis of the clinostat and the seed axes an increasing number of roots responded by bending in the direction of the centrifugal acceleration ($< 2.2 \times 10^{-2}\,g$); a response to gravity was not observed. As a consequence, the threshold value for the perception of mass accelerations was assumed to be near $4.3 \times 10^{-3} g$. In cooperation with Romas Laurinavicius (Institute of Botany, Vilnius, Lithuania) we also used a centrifuge-clinostat with two orthogonal axes to simulate weightlessness (Laurinavicius et al. 1998). For both cress roots and hypocotyls, the threshold value has been shown to be approx. $4 \times 10^{-3} g$. — We had to prove this in orbit!

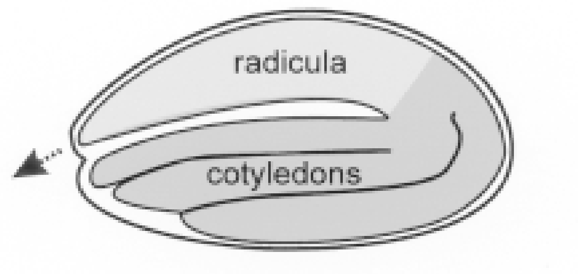

*Fig. 1. Longitudinal section through the seed of garden cress (*Lepidium sativum *L.). The tip of the curved radicle and the arrow point in the direction in which the primary root develops in simulated weightlessness and real microgravity (autonomous development). (Modified after Sobick and Sievers 1979)*

In addition to the physiological results, Volker found that the structural polarity of statocytes developed in that stimulus-free environment of the fast-rotating clinostat (Sievers et al. 1976). This was the first step to the verification of intracellular automorphogenesis (Pfeffer 1904: "Automorphose" of the whole plant; cf. Section 3).

It should be added that we also used the fast-rotating clinostat to test the positioning of statoliths in the positively gravitropic *Chara* rhizoid under simulated weightlessness (Cai et al. 1997). Both the rhizoid and the cress root were also subjects to evaluate the three-dimensional clinostat as a simulator of weightlessness (cf. Section 3 and 4; for review Hoson et al. 1997). In order to understand these results it is necessary to learn about our experiments under real microgravity.

3. The Spacelab-mission D1

On November 4, 1985, some US newspapers

reported on the German Spacelab-mission D1 aboard the Space Shuttle Challenger. In the photograph "shuttle gardening" (Fig. 2), which was made by the Associated Press from a screen during the mission, one sees the smiling Dutch astronaut Wubbo Ockels displaying our culture container with cress roots that developed and grew inside spacelab. It is obvious that this AP-photograph was used as a representative symbol for the early success of the D1 mission. Today I have the impression that the consequence of these reports in the newspapers was extraordinary publicity, and that publicity became a valuable stimulus for future funding of our research.


Shuttle gardening

USA TODAY • MONDAY, NOVEMBER 4, 1985

AP

SPROUTS IN SPACE: Dutch astronaut Wubbo Ockels displays garden cress sprouts growing inside Spacelab aboard the space shuttle Challenger. The European mission ran smoothly Sunday despite earlier problems — including a nitrogen-oxygen leak found Saturday and a small fire in White Sands, N.M., that damaged Challenger's communications link with Earth. NASA is expected to decide today whether Challenger has enough fuel to extend the mission one day to Thursday.

Fig. 2. Reports of US newspapers, The Journal and Courier, The New York Times, *and* USA Today, *on the early success of the German Spacelab-mission D1 aboard the Space Shuttle Challenger showed this photo of the Dutch astronaut Wubbo Ockels showing our culture container with primary roots of cress, which developed and grew on board.*

In the culture container (Fig. 2) most roots are nearly straight and form a constant angle with respect to the black seed plate; the few exceptions can be explained by factors like hydrotropism, which may occur if roots develop too close to the walls of the culture container. In the first and third row most of the root tips point to the right and in the middle row to the left. This difference is determined by the orientation of the radicle within the seed coat (Fig. 1), and the pattern is the result of the specific arrangement of the seeds in the seed plate (Volkmann et al. 1986 a).

The main results of our first spacelab experiments are (in comparison with ground controls, including simulated weightlessness, cf. Section 2):
- from the shape and growth direction of most roots it must be concluded that the microgravity environment in the culture containers was stimulus-free
- the germination rate of seeds and the development of primary roots were optimal
- the roots grew straight in the direction that was given by the tip of the radicle: Pfeffer's (1904) "Automorphose" at the organ level does exist
- slight circumnutations of the roots were observed
- the development of structural polarity in statocytes is genetically determined (and not dependent on other factors): Pfeffer's (1904) "Automorphose" does also exist at the cellular level
- amyloplasts were distributed at random in the statocytes
- their starch content was reduced
- the amount of ER and the diameter of lipid bodies were increased in the statocytes.

Some of these results were confirmed by experiments on board of the Bion-10 satellite (Laurinavicius et al. 1996) thanks to cooperation with the Institute of Biomedical Problems (Moscow, Russia).

I regret that we could not make the necessary second control in the spacelab. A 1 *g* reference centrifuge was not at our (or better, our astronauts') disposal in the spacelab (because of the cost); our friends from Paris were in a better situation (Perbal et al. 1986).

The spacelab experiments required absolutely new (but also very time consuming) preparations, which were done by Harald Behrens and Dieter Volkmann with the help of Leo Schwarz (of our institute's workshop) and the ERNO company (now ASTRIUM) in Bremen. The design of the culture containers was the task with thehighest priority. It had to allow correct positioning of the dry seeds on the seed plate (so that the germinating radicle could find enough free space to develop as primary root; cf. Section 2). In order to get electron-microscopic photos from unstimulated cells we had to convince NASA that chemical fixation aboard spacelab was absolutely necessary. To my knowledge that hazardous procedure was done for the first time in a Space Shuttle during the D1 mission. The astronauts had to exchange the humid air in the culture container with the liquid fixatives. Try doing that in microgravity! This was tested by the US astronaut Bonnie Dunbar during the few seconds of microgravity aboard an airplane making parabolic flights over the Gulf of Mexico. For more details see Volkmann et al. (1986b).

Our first biological results in a spacelab were only descriptive and in a classical way preliminary. They had to be repeated, with both types of controls: in flight and on the ground. Especially the causes of the increase of ER and of the diameter of lipid bodies as well as the decreased starch content in the amyloplasts of statocytes needed to be analysed. An astonishing result was the fact that during the evaluation procedure of the three-dimensional clinostat as a simulator of weightlessness we confirmed most of these flight results. “We” means our Japanese colleagues and friends Yoshio Masuda, Takayuki Hoson, and Seiichiro Kamisaka (from Osaka City University) who invited Brigitte Buchen from our group. They had designed and constructed the instrument and the Bonn people brought the subjects. Under simulated weightlessness we again found the increase of ER and of the diameter of the lipid bodies, the reduction of starch, the random distribution of amyloplasts, the structural polarity of statocytes etc. (for review Hoson et al. 1997). The instrument is good!

However, we were mainly interested in discovering molecular events of the stimulus transduction chain. We wanted to understand the very first steps. The questions are: how is the work done by gravity on statoliths transferred to competent cell structures, and what are the structures that transduce the gravity stimulus into internal physiological signals? During the shortest effective stimulation time of 0.5 seconds the statoliths are unidirectionally displaced by only 8 nm (cf. Section 4)! A further important point is the analysis of threshold values (minimum of stimulation time, mass acceleration, dose, and angle). This was partly studied much later (Volkmann and Tewinkel 1996; see, however, Hejnowicz et al. 1998).

What was the reason for such a delay? It was the terrible Challenger disaster early in 1986. As a consequence, the next flights of Space Shuttles were postponed.

4. The TEXUS sounding rocket

In Fig. 3, a parabola of a rocket flight is shown. The rocket moves from the ground to the vertex of the parabola in approx. 250 km height and back. Microgravity is provided during approx. 6 minutes. Dieter Volkmann proposed using this instrument. The main research with *Chara* rhizoids

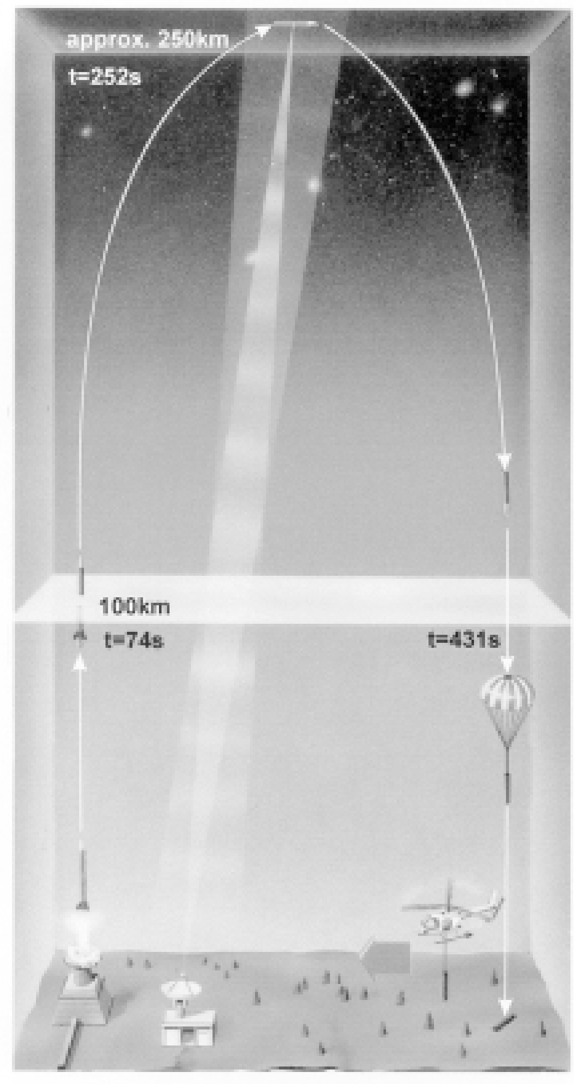

Fig. 3. The parabola of a TEXUS rocket flight.

was done by Brigitte Buchen and Markus Braun (Fig. 4) at the satellite station Esrange (near Kiruna, Lapland, Sweden) where the rockets are launched. The results were revolutionary because for the first time we used a microscope in microgravity, and observed by videomicroscopy living rhizoids during a rocket flight. The most suitable cell type was the *Chara* rhizoid because of its transparency. We saw on a screen (and then on video tapes) how statoliths move in microgravity (Volkmann et al. 1991). The shape of the statolith complex changed from a transversely oriented lens into a longitudinally oriented spindle. The statoliths moved in the direction of the cell base, which was just opposite to the originally acting gravity vector. The same result was observed after chemical fixation of both rhizoids and cress roots during flights.

Later this new distribution of statoliths in rhizoids was also found in simulated weightlessness (cf. Section 2; Cai et al. 1997; for review Hoson et al. 1997) as well as in microgravity during the spacelab mission IML-2 (Braun et al. 1996). All these results demonstrate that the limited basipetal transport of the statoliths is an active one which is proven by the use of the actin-disrupting drug cytochalasin (Buchen et al. 1993). We concluded that on Earth the position of statoliths in both rhizoids and statocytes depends on the balance of two forces, i.e., the gravitational force and the counteracting force mediated by actin microfilaments. The innovating consequences are: in a normal vertically oriented cell the statoliths are dynamically suspended in a network of actin microfilaments (which is obvious in the *Chara* rhizoid and protonema), and the sedimentation onto a floor may be less important for the understanding of stimulus transduction in statocytes of higher plants. By dynamic stimulation the statoliths are displaced in the three-dimensional network of actin microfilaments.

Fig. 4. Brigitte Buchen and Markus Braun in front of a TEXUS rocket. The open windows allow a look at the two late access units for in vivo videomicroscopy and chemical fixation of Chara *rhizoids and protonemata.*

From this new observation and interpretation we developed a new hypothesis for the transduction of the gravity stimulus in root statocytes (Sievers et al. 1991) that can now be found in textbooks. The hypothesis takes into account the following aspects: (i) In the statocyte the actin microfilaments are under tension. The main force, holding the tensional force in equilibrium, is supplied by the cortical membranes (ER, plasma membrane) to which the actin microfilaments are anchored. (ii) Statoliths, which are connected to the actin microfilaments by myosin must influence the tension due to gravity, thus this tension must have a component dependent on gravity. (iii) When a root is tilted, the direction of this component is also changed. Accordingly, the original tension of actin microfilaments is disturbed and this disturbance can be transferred from the interior of the statocyte to its cortex. (iv) If the actin microfilaments are linked to mechanosensitive ion channels in cortical or even in statolith membranes, the disturbance could cause an asymmetrical activation of the channels and thus bring about directional ion transport. The cytoskeleton could act as an amplifier. Such a hypothesis may also explain how the shortest stimulation time of 0.5 seconds (cf. Section 3) may be effective.

It was relatively easy to visualize the actin cytoskeleton in the *Chara* rhizoid and protonema (for reviews Sievers et al. 1996; Braun 1997; Braun and Wasteneys 2000). It is not so easy to visualize the actin microfilaments in root statocytes as Alessandra Kreibaum at first demonstrated (Baluska et al. 1997). However, an indirect method, namely space experiments, may help to understand the role of the actin cytoskeleton in graviperception (Volkmann et al. 1991; Smith et al. 1997; Staehelin et al. 2000; Driss-Ecole et al. 2000). These four groups of authors registered very specific displacements of statoliths in microgravity, which can only be explained by active transport mechanisms mediated by the actomyosin system.

All preparations for the TEXUS rocket experiments were made in cooperation with Paul Blasczyk and Horst Laubach (of our institute's workshop) and the people of the ERNO company (now ASTRIUM) in Bremen. The culture chambers that were located in the modules of the rocket were different for microscopy and for chemical fixation. As the rocket was not protected against the vacuum of space, the culture chambers had to be vacuum tight. The prototype of a culture chamber was designed and constructed in our workshops and was tested by ERNO. Subsequently the first spin off came back to our institute: ERNO ordered dozens of culture chambers.

Brigitte tells us: "Most exciting was the first experiment with *Chara* rhizoids in Esrange. By no means were we sure that the rhizoids would remain at their original place within the thin agar layer, and the 6 min of microgravity was a really short time to find the rhizoid on a monitor that had been set before launch of the rocket. Stuck in an explosion-safe room, staring at the screen and at lots of flickering diodes and numbers, hearing the noise of the rocket's take-off 50 m away–the whole atmosphere was very exceptional for biologists. The rhizoids were re-focused during the flight by telecommand. The first picture on the screen already proved that the experiment was successful! This message was immediately transmitted from Esrange to Bonn by telescience, and our whole group participated in this important event!

Another anecdote may illustrate a profound difference between TEXUS and Space Shuttle experiments. The intimate cooperation between technical teams and investigators saved one of our TEXUS experiments literally in the last minutes. Briefly, we noticed with panic that rhizoids were growing out of the observation frame shortly before launch. I hectically prepared a spare cuvette and fresh fixative, the ERNO chief ingenieur Dieter Grothe and Markus hurried to the rocket launcher, climbed the rocket–which was already ready to be launched–and replaced the cuvette in the module–only several minutes prior to take-off. Such latest access handling would be impossible during a Space Shuttle mission. – A last remark about one of our spacelab missions (IML-2): In the Hangar L at Kennedy Space Center in Florida the *Chara* rhizoids grew extraordinarily fast due to an unexpected increase of the lab temperature. When we transferred these cells to the lower temperature of the Shuttle storage locker during a pre-flight test, we were horrified to see that all rhizoids just died. A shocking moment—to have no samples for the flight! Fortunately, we found a solution in the last moment: reducing the temperature of further culture chambers stepwise to the required degree saved our experiments."

5. Conclusion

The reader can see that we fulfilled the postulate (cf. Section 1): a space experiment should be well prepared on ground, including simulation of weightlessness with suitable (not the classical!) clinostats. From the scientific point of view the question arises: if the use of the right type of clinostat is sufficient, would space experiments be superfluous? The answer is: No. There is no doubt that the multitudinous experiments that will be developed by ingenious scientists in the future need larger and more continuously unstimulated plants (and animals). Furthermore and extremely important: there are and will be many more problems to study in microgravity than our case: stimulus transduction.

This article is not a review. Those readers who are interested to know more details are invited to look at the recent references, some of which are reviews (Sievers et al. 2000). As the title says I wished to write down some ideas and facts on the fascinating transition from Earth to space that was made by the Bonn group in the different experiments. We all learned how extremely mobile plant biology can be. Neither the Kennedy Space Center in Florida nor Esrange in Lapland are too far away. I do not know the answer to the question: What was the best environment for us, the sunshine and the alligators in Florida or the snow and the elks in Lapland? We cooperated with colleagues from Japan, China, Korea, Russia, Lithuania, Poland, Slovakia, Norway, Switzerland, The Netherlands, France, Spain, the USA, and surely from Germany. We saw each other at the annual meetings of the American Society for Gravitational and Space Biology (ASGSB), the Committee on Space Research (COSPAR), and the European Low Gravity Research Association (ELGRA). Especially fruitful occasions were the series of six Gordon Research Conferences "Gravitational Effects on Living Systems" in New Hampshire (with the lobster dinner at the last evening), the European Symposia (ESA) "Life Sciences Research in Space," and the international workshop "Plant Biology in Space" in Bad Honnef near Bonn (Sievers et al. 1997). Today's construction of the International Space Station is an excellent example of an extra-global, international and interdisciplinary network for future research in space.

Acknowledgements. *First of all I thank all astronauts who excellently carried out our experiments on board of the Space Shuttles. Thanks also to Paul Blasczyk, Horst Laubach, and Leo Schwarz (of our institute's workshops) as well as to the people of the ERNO company (now ASTRIUM) in Bremen and of DORNIER in Friedrichshafen for their ingenious help. As I did in the article "Gravitational Biology in Bonn" (Sievers 1999), I thank once more my dear colleague, Mary Musgrave (University of Massachusetts, Amherst, MA), for inviting me to write some thoughts on my experiences in biology. Again thanks to all persons who cooperated with me and to all institutions that spent the money (see Sievers 1999); special financial support by Deutsches Zentrum für Luft- und Raumfahrt (DLR) on behalf of Bundesministerium für Bildung und Forschung (50WB9998).*

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Group Convenes to Explore Plant Rootzone Dynamics in Microgravity

A workshop entitled "Plant Production Systems for Microgravity: Critical Issues in Water, Air and Solute Transport Through Unsaturated Porous Media" was organized and held at Johnson Space Center from 24-25 July 2000. This was a first step in identifying critical research issues concerning water, air, and solute transport in solid substrates used to grow plants in microgravity.

The meeting afforded an opportunity to establish new multidisciplinary research alliances and to define and clarify the emerging area of production-oriented "Space Farming" within the ALS community. Discussions covered numerous topics including microscale fluid physics, optimization of water retention and aeration, design of optimal media, the impact of roots on soil properties and on water and oxygen demands, control system integration and sensor development, and the coupling between modeling and experimentation.

A consensus message from the participants to the organizers indicated the need for a modeling toolbox to guide future experiment and hardware design for production oriented ALS plant growth systems. This would serve to maximize the return of valuable data for model verification and hypothesis testing from the numerous NASA-sponsored plant experiments. The participants also stressed the need for performing simple microgravity experiments using drop-towers, KC135 flights, and flight experiments to measure parameters, such as oxygen transport through media and water retention curves for both particulate and fixed-geometry media, for the purpose of formulating and validating the model toolbox for use in microgravity. Although this work is in its infancy, the participants recognized that sufficient data is available for creating a database and for bridging the gap between the many disciplines.

The workshop was attended by soil physicists: Scott B. Jones and Dani Or, Utah State University; Marcel Schaap, U.S. Salinity Laboratory / USDA; Igor Podolsky, Russian Institute of Biomedical Problems; Gerard J. Kluitenberg, Kansas State University; soil chemist Paul Schwab, Purdue University; soil mineralogist Doug Ming, NASA / JSC; plant physiologists Susan Steinberg, Johnson Space Center / NASA and Oscar Monje, Dynamac Corp. / KSC; flight hardware developers and experimenters Gail Bingham, Space Dynamics Lab, Bob Morrow and Peter Kotska, Orbitec, Weijia Zhou, WCSAR, Paul Scovazzo, BioServe, Howard Levine,Dynamac Corp. / KSC; fluid physicists J. Iwan D. Alexander and Nihad E. Daidzic, The National Center for Microgravity Research on Fluids and Combustion / NASA; and Donald Henninger, Advanced Life Support Program.

Oscar Monje
Dynamac Corp., KSC

CoSPAR 2000 Highlights "Life Sciences as Related to Space"

The 33rd COSPAR meeting was held July 16-23, 2000 at the Warsaw University of Technology in Poland. The Committee on Space Research (COSPAR) was established by the International Council for Science in October 1958. The primary purpose of COSPAR is to "provide the world scientific community with the means whereby it may exploit the possibilities of satellites and space probes of all kinds for scientific purposes, and exchange the resulting data on a cooperative basis."

John Kiss, Volker Kern, and Karl Hasenstein outside of the main building of the Warsaw University of Technology during 33rd COSPAR meeting.

COSPAR is an interdisciplinary scientific organization concerned with international progress in all areas of scientific research carried out with space vehicles, rockets, and balloons. Many ASGSB members participated in the meeting as part of Commission F: Life Sciences as Related to Space.

The meeting provides a dynamic international forum and has been traditionally an opportunity to meet space life scientists from the former Soviet Union.

Abstracts from the 33rd COSPAR meeting are available on-line at http://www.mpae.gwdg.de/COSPAR/COSPAR.html. The next meeting will be held in conjunction with the World Space Congress in Houston in October 2002.

John Kiss
Miami University

Gravitational and Space Biology to be Featured at the AAAS Meeting in February 2001

Increasingly, we are realizing that the program of human exploration and habitation of space must be centered in biology. Therefore, the American Association for the Advancement of Science annual meeting will play host to two symposia on the topic of gravitational and space biology at its annual meeting to be held in San Francisco from February 15-20, 2001.

Dr. Nina Strömgren Allen of NC State University and Dr. Chris Brown of the Dynamac Corporation organized the first session entitled "Biology Into Space: A Matter of Some Gravity." The speakers at this symposium will discuss the progress made to date in gravitational and space biology and the implications for future directions in research. They tentatively include:

Dr. Don Ingber, Harvard Medical School - "The Cellular Basis of Mechanotransduction"
Dr. Patrick Masson, University of Wisconsin - "Molecular Mechanisms of Plant Responses to Gravity"
Dr. Wendy Boss, North Carolina State University - "Signal Transduction Pathways and Early Responses of Plants to Gravistimulation"
Dr. Robert Ferl, University of Florida - "Taking Plants into Space: Answering Fundamental Questions of Plant Stress"
Dr. Raymond Wheeler, NASA Kennedy Space Center - "Human Life Support for Space Missions Using a Bioregenerative System"

The second session, organized by Ken Souza and Lauren Fletcher of the NASA Ames Research Center, is entitled "Human Exploration of Space." This symposium will address the scientific and technical challenges associated with the eventual exploration of the solar system by humans, with a particular focus on a potential mission to Mars. The tentative list of speakers is:

Dr. John Charles, Johnson Space Center - "Mars Mission Study Results"
Dr. Laurence Young, MIT and the NSBRI - "Biological Challenges of Long Duration Spaceflight"
Dr. Christopher McKay, NASA Ames Research Center - "Destination Mars"
Dr. John Hines, NASA Ames Research Center - "Technological Challenges of Biology in Space"

For more information on these sessions contact the organizers. For more information on the AAAS Annual Meeting, go to www.aaas.org/meetings/2001. See you there!

Submitted by Chris Brown (cbrown@unity.ncsu.edu)

NASA Research Announcement (NRA) for Cellular and Macromolecular Biotechnology

The National Aeronautics and Space Administration (NASA) announces a solicitation for scientific research proposals. The release date for the NRA is August 4, 2000.

NASA RESEARCH ANNOUNCEMENT, NRA-00-HEDS-03
CELLULAR AND MACROMOLECULAR BIOTECHNOLOGY

Proposals requested by this Announcement may be for ground-based research and technology investigations or for space flight experiments designed for the early phase of utilization of the International Space Station.

This solicitation will be available electronically via the Internet at: http://peer1.idi.usra.edu/

Letters of Intent Due: September 6, 2000
Proposals Due: October 27, 2000

Paper copies of this NRA are available to those who do not have access to the Internet by calling (202) 358-4180 and leaving a voice mail message. Please leave your full name and address, including zip code and telephone number with area code, along with the name of the NRA you are requesting.

Questions regarding this NRA may be addressed to NASA Headquarters, Code UG, Washington, DC 20546, Attn: Dr. Steve Davison, Tel: (202) 358-0647.

Robert Woods

Opportunities

Postdoctoral Position–Plant Space Biology

Requirements:

A Ph.D. or equivalent in the plant sciences. Experience and knowledge in plant physiology & cell biology.

Additional Desired Qualifications:

Experience in gravitational & space biology and molecular biology.

Description:

This position is funded by NASA for the definition and development stages of a space flight project to study phototropism in plants. The major goals of this research are (1) to better understand cellular mechanisms of phototropism in plants and (2) to determine the effects and influence of gravity on light perception in plants. Specifically, we plan to use microgravity to facilitate studies of phototropism in roots and hypocotyls of young seedlings of *Arabidopsis*.

Major Duties:

The successful candidate will be responsible for ground-based testing related to this project. He/she will be responsible for establishing correct culture conditions and time tables for conducting experiments in space. The person will need to travel to NASA sites for hardware development and testing. He/she will also participate in writing reports and manuscripts.

The anticipated salary is $29,500 per year with full medical and retirement benefits.

Application:

Send a curriculum vitae with three letters of reference to:

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Department of Botany
Miami University
Oxford, OH 45056 USA
e-mail: kissjz@muohio.edu
Tel.: 513-529-5428
Fax.: 513-529-4243

2000 ASGSB Membership Directory

The following directory of the American Society for Gravitational and Space Biology contains a listing of members as of August 31, 2000.

Fax numbers and e-mail addresses are included in this directory as provided by the members. Please notify the Executive Director (e-mail: asgsb@usra.edu) if there are any corrections, additions, or changes. You may also make corrections into the online ASGSB Membership Database via the ASGSB web site at http://www.asgsb.org

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