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Paper Session I-B - The NASA Space Life Sciences Training Program: Ten Years of Accomplishment

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The NASA Space Life Sciences Training Program - Ten Years of Accomplishment

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ABSTRACT

The NASA Space Life Sciences Training Program (SLSTP) is now in its tenth year of training future scientists and engineers to meet the needs of space life sciences research and operations. The SLSTP provides six weeks of intensive study at the Kennedy Space Center for top undergraduate students with an interest in life sciences. The program consists of lectures, demonstrations, hands-on research, discussions, and other activities designed to provide an understanding of teamwork, flight experiment development, payload processing, and the unique requirements and opportunities imposed by the space environment. Over 330 undergraduates have completed the program. Since its inception, the SLSTP has continuously evolved to meet the changing needs of the students and NASA's space life sciences interests. As part of their curriculum activities, the SLSTP students have made significant contributions to space life sciences research and have supported Shuttle flight experiments. The long-term benefits of the SLSTP are just beginning to be seen. Former students are now taking positions where their experience and intelligence will help guide the Space Program into the future.

INTRODUCTION

The Challenge Before Us

The complexity of technology and the knowledge-base required to support proposed Space Station, lunar and Mars missions is expected to continue to grow in the near future. New areas of exploration and challenge will be encountered as the length of space flights increases and as we stretch our reach to realms more distant from the Earth's surface. Greater utilization of space as a vantage point for the observation and study of our planet and how we are affecting it is predicted. Use of space as a platform and environment for commercial enterprises has already begun. In the area of space life sciences, the challenges of the near future go far beyond the not insignificant technological difficulties and the economics of continued space efforts. The space environment presents situations never previously experienced by living beings as they evolved in the gravity and sheltering atmosphere of the Earth. Our experience with microgravity, space radiation, and the vacuum of space is nearly zero when compared to our experience with most environments on the Earth's surface. There is a great need for a basic understanding of how people, animals, and plants will react and adapt to the space environment. Most people believe that people can live and work in space indefinitely. It is believed that we can take living organisms and systems into space for our utilization there. Our limited attempts to maintain life in space have provided much insight but indicate many problems...
which must be overcome. None of those problems seem insurmountable. However, the fact remains that when asked many questions about long-term space flight, we must still answer "We don't know."

Yesterday's and today's "space experts", who have brought space activities to their current levels, will not be available forever. There is a flow of talent through all long-term endeavors as participants join, grow, age, and eventually retire. A highly trained, intelligent, and dedicated team of new scientists and engineers will be needed to meet the many challenges involved in continuance of space activities. Where will this new blood come from? How will the necessary training and knowledge be transferred to these young scientists and engineers? Indications are that many bright and talented young people may be turning away from participation in space research and operations due to the lure of high profit and excitement in other technological areas. Recent setbacks, bad publicity, and a perception of a bureaucratic and politically overburdened Space Program also undoubtedly contribute to the decision of many talented people to look elsewhere when they choose a career. A problem also exists with many of those who do eventually choose a space career. There is a perceived deterioration in the educational system in the math and sciences. Today's graduates may not have the background and training of those graduating twenty years ago, much less a sufficient understanding of new scientific concepts and complexities. Sadly, the perceptions of space, possessed by many young people, are those obtained from TV shows such as Star Trek® or The Jetsons®. Although popular space-related entertainment may encourage some to look toward possible space-related careers, the realities of living and working in space are usually distorted or lacking. Aerospace companies and NASA expend significant time and effort correcting some new employee's perceptions before they can be truly productive or be confident enough not to make potentially disastrous mistakes.

Goal of the Space Life Sciences Training Program (SLSTP)
The SLSTP is one way by which NASA is attempting to create a pool of new scientists and engineers to meet the needs of the future. In spite of problems with the educational system and in spite of other career areas luring people away, there are many very intelligent and potentially productive young people interested in possible space research and operations. At the college level, most of these know little about available opportunities to pursue those interests. The SLSTP is designed to provide an introduction to NASA's space life sciences interests to the best and brightest of today's young college students. The SLSTP encourages these students to continue in space life science careers. SLSTP recruiting efforts particularly focus on minorities and other underrepresented groups. The objectives of the SLSTP are long-range. It is not expected that SLSTP graduates will immediately step into positions in space research and operations. Rather they will continue on in college and complete their education with more knowledge and a better understanding of the requirements for a career in space life sciences. This knowledge will help the students make better course selections, receive a better education, and open pathways into many space-related activities.
SLSTP Structure Overview

1994 is the tenth year of operation of the SLSTP. Detailed descriptions of the SLSTP curriculum structure have been presented in a previous report*. The program is six weeks long and is conducted in the life science support facilities at The Kennedy Space Center (KSC) during June and July. Currently, 40 students are selected, nationwide, to participate in the program. Student recruiting, logistical support, and curriculum advice is provided by Florida A&M University, College of Pharmacy and Pharmaceutical Sciences. Curriculum development and implementation is provided by the life science support contractor at KSC, The Bionetics Corporation, under NASA management from the Payloads Projects Management Directorate and the Biomedical Operations and Research Office. Funding and sponsorship is provided by the NASA Headquarters Office of Life and Microgravity Sciences and Applications and the Office of Equal Opportunity Programs.

To alter or reinforce a student's career goals, the SLSTP must have a strong and lasting impact. To accomplish this the SLSTP has evolved into an intensive study program employing presentation of diverse technical information, hands-on participation, analytical thinking, and teamwork. To accommodate all of these a variety of educational formats have been developed and are used. The SLSTP curriculum structure is currently composed of: (a) a formal lecture series, (b) laboratory and field research activities, (c) tours of major KSC facilities, (d) demonstrations, (e) conceptual design projects, (f) discussion sessions, and (g) student presentations.

It is calculated that the students spend two thirds of the slightly more than 1000 hours of the six-week summer session involved in curriculum activities (the remainder being mostly used for sleep). Most scheduled activities occur during the normal 8:00 to 4:30 workday but considerable independent and team work is required of students during the evenings and on weekends. A balance of approximately 30% lecture, 40% lab and field activities, and 30% other scheduled activities has evolved to keep students interested, active, and allow coverage of all of the concepts desired.

With the above introduction the following information is provided detailing some of the more interesting lessons learned and noteworthy accomplishments of the past ten years of conduct of the SLSTP.

WHAT WE HAVE LEARNED ABOUT EDUCATING SLSTP STUDENTS

SLSTP students are often referred to as the "cream of the crop". Even though these students are the best of the best several educational needs have become apparent. From interaction with these students a picture has developed of what is needed in education of young people to better allow them to compete and function in the global community of tomorrow. The SLSTP staff has not only used this picture to continually improve the SLSTP but has also work with local schools and other educational organizations to improve local area educational priorities. A few examples of the observations of the SLSTP staff in this area follow.

Teams
Many students entering the SLSTP come into the program with a competitive attitude. "Teamwork" is known mostly only from a sports perspective. It is a difficult transition for some students to go from trying to be better than everyone else to being a contributing member of a student team. For this reason the SLSTP has provided more and more activities over the years designed to instill teaming concepts in the students. Outside of the formal lecture series nearly all activities are now designed to be implemented by a team of students and staff. Some activities are designed specifically to demonstrate how a team can function and how team problems can be solved.

Hard Work and Pride of Accomplishment
The intensive nature of the SLSTP is considered important to SLSTP's success. Experience indicates that students who are continuously challenged perform better and learn more. The stress and strain placed on the students during the six weeks is considerable but is closely monitored and not considered excessive for the short six-week period. The workload imposed by several of the scheduled activities can be controlled during implementation to regulate stress and tension levels should minor adjustments be needed. The hard-work, long hours, and high expectations approach used by the SLSTP may not be successful with all student programs. However, it is a tribute to Florida A&M University recruiting and student selection processes that the students involved in SLSTP handle without great difficulty the workload and in most cases enjoy the fast-paced and challenging experience. A frequently heard comment from former students is one of surprise to find that they could accomplish so much. Many comment that they find their regular classes at their colleges and universities are somehow easier after the SLSTP summer experience.

Analytical Thinking
By its nature, the SLSTP student selection process tends to select students who are thinkers. In spite of this fact, it has been observed that SLSTP students prefer to be spoon-fed facts and answers. This may be a reflection of the standard methods used in many university and college lecture settings. When presented with contradicting points of view or when asked to use available information to derive answers many SLSTP students are either stunned or complain loudly. SLSTP students want to be creative but frequently are comfortable with being creative only in artistic ways. The SLSTP curriculum, therefore, has evolved to emphasize analytical thinking. Students are asked to create and design space-related systems and are critiqued by staff members who may guide the students but rarely give them direct solutions to their design problems.

Lack of History
From an information transfer perspective, we have observed that most SLSTP students fall into one of two categories. Category one includes the students who are exceptionally well informed of facts and figures related to manned space flight. These students are a wealth of trivia and other information about every aspect of the Space Program since the dawn of time and can talk for hours about past missions. Such students participate in SLSTP as a means for refining their knowledge and as a way of making contacts which might help them in the future. These students are rare, accounting for probably less than 10% of student participants. Most students fall into category two. These students are exceptionally bright but with not more than superficial knowledge of manned space flight. They rarely initially know the difference between Spacelab, Spacehab, Skylab, and Space Station. Many are unaware of any details of Mercury, Gemini, Apollo, and Space Shuttle missions. Most know that we have gone to the Moon but few know when, how, or how many
times. These students come to the SLSTP to be introduced to new ideas and concepts. When questioned, many of these students explain that coverage of man's exploration of space is presented as part of history courses they have taken. Frequently, it is explained that history instructors run out of class time before getting to historical coverage of the last thirty years, so space exploration and manned space flight is skimmed over or never covered. Most of what is known about space flight by these students is learned from television programs and/or books they may have read.

The SLSTP has attempted for several years to present a historical perspective on manned space flight to fill in this obvious gap in student understanding. In recent years, however, the pressure to teach more science and offer information on the many potential future opportunities in space has resulted in less time available for history. Students are encouraged to watch videos detailing the history of the Space Program (i.e., PBS Spaceflight Video Series) as the primary means of conveying this information.

SCIENTIFIC ACCOMPLISHMENTS OF THE SLSTP

Data Collected and New Ideas Contributed

The primary goal of the SLSTP is to educate students. However, a valuable side benefit of the yearly implementation of the SLSTP is the collection of valid scientific data. Over the past 10 years, SLSTP students have contributed significantly to ongoing research in the areas of human cardiovascular physiology, muscle physiology, and vestibular physiology. Students have volunteered as test subjects and have worked as test conductors to collect an extensive amount of data. Students have participated in examination of a variety of responses to simulated weightless environments and have also collected much "normal" data which has been used for comparison to data collected under simulated and real flight conditions. This data has been used to support at least six scientific publications in the area of human physiological responses to weightlessness.

Similarly, students have contributed to support of plant and animal Space Shuttle flight experimentation. Students have been actively involved in nearly all stages of flight experiment development and implementation, from initial conceptualization of an experiment to post-flight follow-up testing and analysis. As part of the earliest stage of development of a flight experiment, the SLSTP students have provided ideas and designs for systems which could be used to support microgravity experiments. SLSTP students have assisted in two plant growth experiments flown aboard the Space Shuttle and have worked in development of several more. The SLSTP students have become valuable tools in testing proposed flight protocols and prototype hardware. The students' many hands and minds allow for testing of many ideas which an investigator alone would not be able to pursue. To name a few examples, this type of support has been provided in the areas of:

- inflight harvest and fixation of plant and microbial material,
- definition of optimal conditions for the development of invertebrate embryo development,
- definition and testing of optimal conditions for the support of plant growth in microgravity, and
- development of microgravity suitable diets for rodents.

SLSTP students have played a significant role in research associated with NASA's Controlled Ecological Life Support System (CELSS). Students have worked in projects ranging from engineering tests of various proposed hydroponics systems to
evaluation of the palatability of foods grown in CELSS biomass production subsystems.

Recently, SLSTP students have moved into a growing area of biological activity at KSC not always directly related to Space Shuttle flights. The students have joined resident ecologists in studies of the KSC environment. Students have used radio telemetry to track endangered animal species and have been involved in studies related to the effects of global burning and elevated atmospheric carbon dioxide levels.

Data collected by students is usually pooled with data collected over a period of years by the resident research staff. It is impossible to determine the exact amount of contribution of the SLSTP students but over the many years of conduct of the SLSTP the contribution is undoubtedly significant.

Driving Force

SLSTP student participation in life sciences research and operations at KSC has had another possible side-effect. The existence of the SLSTP at KSC and the knowledge that activities must be prepared and ready for the annual influx of summer students is probably a driving force in getting things done. It is possible that the life sciences research laboratories at KSC would be as productive in the absence of the SLSTP students but it is just as possible that without the tight timelines imposed by the SLSTP summer session that some research projects would progress more slowly. It is frequently said that research is not conducted on a schedule but is a continuously changing process, growing and branching with each discovery. The SLSTP not only offers the opportunity to explore branches which might otherwise have been overlooked but forces researchers, at least to some degree, to schedule their work several months in advance. It could be argued that the time spent by the resident staff in support of SLSTP could have been used to more efficiently move research efforts forward. On the other hand, the requirement of support to forty students with a variety of hands-on activities for six weeks may also move research efforts forward and stimulate development of new research directions. Undoubtedly, SLSTP has influenced research at KSC, if not in quantity, then in the directions taken by researchers so as to meet there needs and those of the program.

CREATION OF THE RESOURCE POOL

Students as Products of the SLSTP

As stated before, the primary goal of the SLSTP is to create a pool of scientists and engineers that will support the Space Program in the future. Unfortunately, how well SLSTP efforts meet this goal is perhaps the most difficult to measure. It must be understood that after the six-week summer SLSTP session many of the participants virtually disappear back into their college settings. Most SLSTP participants have a long college road to travel, after the summer session, before they are in a position to substantially benefit the Space Program. Attempts to track former students are thwarted by the fact that many students change majors, change schools, and change mailing addresses several times before graduating and entering the workforce. There is no practical way to force busy students to keep SLSTP management informed of their academic and career status. Survey forms sent out to collect information are returned by fewer and fewer students as the time increases since their SLSTP experience. After several years, much of the information gathered about former students comes from cards and letters exchanged between students and staff from friendships that were established during the summer sessions. In spite of the long time required for former students to show a return on NASA's investment and in
spite of the difficulties associated with tracking former students, strong evidence is accumulating that the SLSTP is successful in meeting the program's goals. Length restrictions on this paper do not permit inclusion of a detailed listing of the known links between former students and space-related activities. However, several categories of continued student contact with space-related work are provided below.

One example of the success of the SLSTP is demonstrated by the number of former participants who are now enrolled at NASA NSCORTs. NSCORTs are university affiliated NASA Specialized Centers for Operations, Research, and Training and are an ideal next step for SLSTP students interested in continuing with NASA. Created only a few years ago these NSCORTs are enrolling former SLSTP participants as graduate students. Current count indicates that eight former students are enrolled in the Gravitational Biology NSCORT. Several former SLSTP students have also joined the Radiation Biology NSCORT and Environmental Health NSCORT. Representatives of NASA life science NSCORTs realize the value of SLSTP students and most of these NSCORTs are now sending lecturers and recruiters to the SLSTP summer session.

Other NASA affiliated programs such as the Aerospace Medical Residency Program at Wright State University have also noted former SLSTP students as part of their enrollment. Several former SLSTP students have participated in the LARS summer research program at the Langley Research Center. Others have worked as summer interns or are now employees at the Kennedy Space Center, Lewis Research Center, Johnson Space Center, and Jet Propulsion Laboratory. Several have participated in programs at Los Alamos National Laboratory and Argonne National Laboratory.

Several former SLSTP students have reported that they are participating in space-related research at universities or have received NASA funding for internships and special projects. Space-related research at universities is extremely difficult to track since much of this work may occur for years without significant advertisement and is eventually reported through any of a wide variety of professional societies and technical journals. One former SLSTP student is author of a widely used Space Flight Handbook which is now in its third edition.

Several former SLSTP students have become representatives of the Space Program and are active in various parts of the country as space educators. Most provide seminars and lectures on their experience to other students at their schools. Many make presentations to elementary and high school students. Many participate in local area space societies and clubs. A former student in the Buffalo, New York area is responsible for numerous space-related courses for children in that area. As a result of inclusion of 19 international students in 1992 in the SLSTP as part of NASA's International Space Year participation, students are now spreading "the SLSTP gospel" worldwide. Not a single former student is known who is not a strong advocate of the Space Program after their summer SLSTP experience.

The total number of former SLSTP students known to be actively engaged in space-related activities accounts for about 20% of the 327 participants, to date. This may not seem like a large figure but it must be remembered that nearly 75% of all former students are still in school and thus have limited opportunity to currently work in space-related activities. It is also important to realize that perhaps only a fraction of space-related activities of former students is known and has been documented. This 20% may be only the tip of the iceberg.
Other People Products of the SLSTP

An originally unanticipated benefit of the SLSTP deals with the staff that is hired yearly to support the program. These people fall into two categories. First are graduate-level Project Assistants hired to support laboratory project activities. Remarkably, it is estimated that better than 80% of all former Project Assistants are still involved in space-related activities. Some are now full-time employees at the Kennedy Space Center or NASA Headquarters. Others are now working under NASA funded projects at universities through contacts that were made during their time with the SLSTP. The other category is the Project Counselors who are faculty-level staff hired to support student logistics and provide guidance and to the students during the program. Many Project Counselors return to their schools with fresh and new ideas for space-related research projects. Many also develop space-related courses for their schools. All have become strong space advocates. One former counselor is currently actively involved in development of an SLSTP at the Johnson Space Center in Houston.

CONCLUSION

The Space Life Sciences Training Program has, without a doubt, changed the lives of many people, from the resident life sciences research and operations staff at the Kennedy Space Center to literally thousands of children and young people who listen to presentations from former SLSTP participants. The SLSTP process has helped to strengthen space life sciences research. The students have helped us understand better what is needed in education. We have attempted to tap the minds of SLSTP students for new ideas and concepts. The ultimate goal of the SLSTP to create a resource pool that the future can draw on is slow in realization but there is strong indication of a growing wave of activity on the part of former students which may eventually help shape the future direction of space activities.