Paper Session II-D - The Collaborative Ukrainian Experiment: (CUE): Opportunities for Collaboration in Science Education and Research

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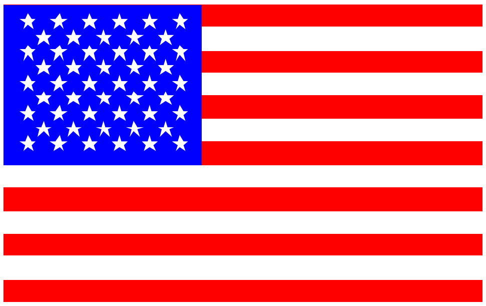

United States of America Ukraine

The Collaborative Ukrainian Experiment (CUE): Opportunities for Collaboration in Science Education and Research.

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Abstract

In 1994, President Clinton of the United States (US) and President Kuchma of Ukraine signed an agreement to support joint activities in space. The National Aeronautics and Space Administration (NASA) and the National Space Agency of Ukraine (NSAU) have developed a joint Space Shuttle mission which will include a Ukrainian Payload Specialist. The Collaborative Ukrainian Experiment (CUE) Mission is targeted for late 1997 and features a number of plant experiments to be carried in plant growth hardware on the Space Shuttle in the middeck. In conjunction with these experiments, an educational component called the CUE TSIPS (Teachers and Students Investigating Plants in Space) is being developed for high school classrooms to participate in the experiment by performing ground-controls. Teachers in both Ukraine and the U.S. have been trained in the protocols of the *Brassica*-Seed Terminal growth In Chambers (B-STIC) experiment. This experiment was developed by Dr. Mary Musgrave at Louisiana State University and designed to investigate the microgravity effects on pollination and

fertilization. To participate in the B-STIC experiment, teachers and students will construct simulated flight hardware and implement plant growth, pollination, and fertilization of a variety of *Brassica rapa*, the Chinese cabbage plant. This variety was developed by the Wisconsin Fast Plants™ program (Williams, 1995) and called the Astroplant™. This plant has been genetically selected and developed for use in spaceflight experiments because of it's small size and rapid growth. The Ukrainian Payload Specialist will perform pollination of the plants in space while students in the two countries do the same in their classrooms. The success of the pollination, seed development, and subsequent generation of plants will be measured in the space and classroom plants. The science and educational collaboration as well as the cultural exchange make the CUE an important activity for both countries.

Background

On May 11, 1995, President William J. Clinton of the United States met with President Leonid Kuchma of Ukraine for the purpose of discussing the U. S.-Ukraine partnership. The Joint Statement on Future Aerospace Cooperation Between the United States and Ukraine, dated November 22, 1994, directed the National Aeronautics and Space Administration (NASA) and the National Space Agency-Ukraine (NSAU) to identify potential experiments and payloads which could qualify for flight on the Space Shuttle and also to create an opportunity for a Ukrainian Payload Specialist (PS) to fly on the Space Shuttle.

The Ukrainian Payload will consist of the following two Space Shuttle flight research facilities to be flown on STS-87: The Plant Growth Facility (PGF) will house experiments to study the effects of microgravity on plant reproduction and photosynthesis; and the Biological Research in Canisters Facility (BRIC) will house experiments to study the effects of microgravity on plant physiology.

The crew for STS-87 has been designated as follows: Commander Kevin Kregel; Pilot Steven Lindsey; Mission Specialist (MS) Kalpana Chawla, Ph.D.; and Mission Specialist Takao Doi, Ph.D. The Ukrainian PS for CUE will be either Leonid Kadenyuk or Yaroslav Pustovyi, with the other acting as the PS mission back-up.

Payload/Experiments on the NASA Space Shuttle

The Collaborative Ukrainian Experiment (CUE) is a collection of plant space-biology experiments scheduled to fly on STS-

87 which the Ukrainian PS will perform during the 16 day mission. Five middeck lockers will house the experiments. The payload is the result of close scientific collaborations between U.S. scientists and Ukrainian scientists (Table 1).

Table 1. Collaborative Ukrainian Experiment Investigations and Investigators.

PLANT GROWTH FACILITY (PGF) EXPERIMENTS

Experiment Description	Acronym	Investigator/Country
Microgravity effects on pollination and fertilization in *Brassica rapa* (*Brassica* Seed Terminal growth In Chambers).	B-STIC	Musgrave/U.S. Kordyum/Ukraine Popova/Ukraine
Effects of altered gravity on the photosynthetic apparatus(*Brassica*-Photosynthetic Apparatus in Chambers).	B-PAC	Guikema/U.S. Hilaire/U.S. Kordyum/Ukraine Kochubey/Ukraine Nedukha/Ukraine Volovic/Ukraine Scherchenko/Ukraine Korneeb/Ukraine Proublova/Ukraine Adamchuk/Ukraine Dvrutskay/Ukraine
Gravity effects on structure,function, and organization of root cells in *Brassica rapa.*	ROOTS	Kordyum/Ukraine Musgrave/U.S. Klimchuk/Ukraine Zaslavsky/Ukraine Prima/Ukraine
Spaceflight effects on gene expression in *Brassca rapa* tissue.	GENEX	Prima/Ukraine Piastuch/U.S. Alkhimova/Ukraine Martynenko/Ukraine
Spaceflight effects on amino acid content in *Brassica rapa* tissue.	AMINO	Kordyum/Ukraine Generalova/Ukraine Zaimenko/Ukraine Sytnyanskaya/Urkraine
Spaceflight effects on phytohormonal content in *Brassica rapa* tissue.	PHYTO	Kordyum/Ukraine Generalova/Ukraine Cherevchenko/Ukraine Musatenko/Ukraine

CUE Educational Program (Teachers and Students Investigating Plants in Space, patterned after B-STIC).	TSIPS	Williams/U.S. Nazarenko/Ukraine

Table 1. Collaborative Ukrainian Experiment Investigations and Investigators (continued).

Experiment Description	Acronym	Investigator/Country
The effects of microgravity on the lipid content of *Brassica rapa.*	LIPID	Kordyum/Ukraine Zolotareva/Ukraine
BIOLOGICAL RESEARCH IN CANISTERS (BRIC) EXPERIMENTS		
Effects of microgravity on differentiation and phototropism in moss protonemata (SPace Moss).	SPM	Sack/U.S. Demkiv/Ukraine Kern/U. S. Tchaban/Ukraine Kardash/Ukraine
Effects of microgravity on the relationship between pathogenisis and cellular carbohydrate content in soybean plant tissue.	SOYPAT	Leach/U.S. Guikema/U.S. Brown/U.S. Nedukha/U.S. Prima/U.S.
Gravity effects on distribution and metabolism of storage statolith starch, localization of cellular calcium, and interaction of elevated ethylene impacting the root/shoot ratios in soybean.	SOYMET	Brown/U.S. Guikema/U.S. Piastuch/U.S. Nedukha/Ukraine Prima/Ukraine

The CUE will utilize the PGF (Plant Growth Facility) used for culture of *Brassica rapa* seedlings, and BRIC (Biological Research In Canisters) hardware for two soybean experiments. A modified BRIC canister will provide red Light-Emitting Diode (LED) lighting to individual Petri dishes for experiments on two species of moss.

The B-STIC experiment, evaluating the effects of microgravity on pollination and fertilization will utilize 16-day-old *Brassica rapa* seedlings. Flowering will begin four days into the mission, at which time the Ukrainian PS will begin to perform daily pollination activities. Flowering is expected through the tenth day of the mission. A simple labeling system will be used to identify individual flowers. This will allow the examination of space environment effects on the events relating to flower development, pollination, and seed development.

The educational component to the payload will emphasize the activities surrounding the B-STIC experiment. which involves pollination and seed development in *Brassica rapa*. Students in the U.S. and Ukraine will perform the pollination of *Brassica rapa* on the ground at the same time that the Ukrainian PS performs the flight experiments in space onboard the Shuttle.

During scheduled down-link sessions from the Shuttle, the Ukrainian PS will speak with students on earth performing the same experiment in their classrooms in the US and Ukraine. This educational component is based on concepts developed by the Wisconsin Fast Plants™ (WFP™) program, which is funded by the National Science Foundation (Williams, 1995). The WFP program utilizes rapid cycling *Brassica rapa* for teaching biology. An associated project is Bottle Biology™ ,in which various pieces of scientific equipment are constructed from plastic film cans, soda bottles, and other disposable containers (Williams et al., 1993).

Scientists from the U.S. have visited and worked in the laboratories of their Ukrainian colleagues and the Ukrainian scientists have visited and worked in the labs of the U.S. colleagues. The Ukrainian Education Component PI has visited the U.S. to meet with U.S. colleagues and the U.S. Education Component PI has been to Kiev, Ukraine to meet with education colleagues and to implement a CUE Teacher Workshop.

The CUE TSIPS (Teachers and Students Investigating Plants in Space) Education Program

The CUE TSIPS education program is based on: 1) a pollination, fertilization and embryogenesis investigation with Fast Plants, replicating the B-STIC flight experiment and 2) additional experiments relating to other flight experiments in the BRIC, in which Fast Plants™ or other plants will be used to demonstrate the process or phenomenon.

A group of master teachers in both countries have been or will be trained in the CUE exercises and techniques and will act as lead teachers for other colleagues. They and their students will run simulated ground-based control experiments and share their data with other teachers, students, and the CUE scientists. The instructional materials are also being shared through teacher training at the NASA centers and across the Internet, e.g., on the Fast Plants™ WWW and gopher servers, for any other teachers who wish to participate.

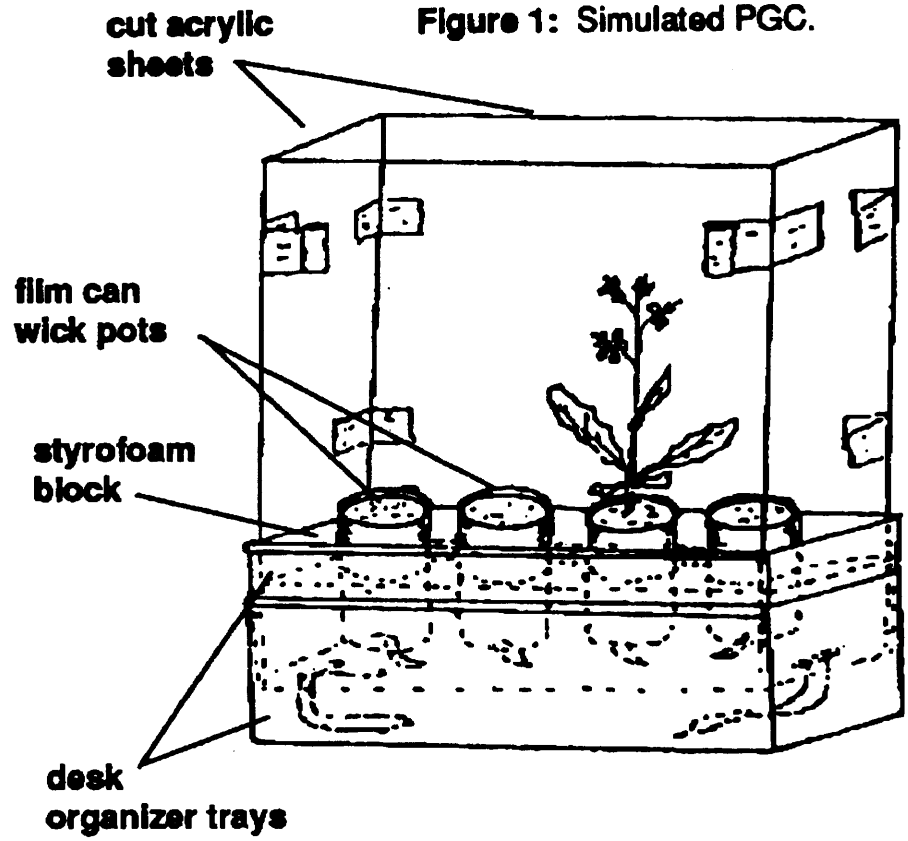
In the United States, master teachers are all experienced Fast Plants™ secondary school teachers who were selected from a pool of applicants. They are already into the experimental "process science" mode with their students and have committed to having their students carry out a subsequent "research" project, based on questions that arise from the real time experiment. The Fast Plants™ Program has designated these teachers to ensure good geographical distribution and also so that there is at least one teacher in proximity to NASA centers: Kennedy Space Center (KSC); Johnson Space Center (JSC), and Ames Research Center (ARC). In Ukraine, the master teachers are select representatives of each of the twenty-five geographical regions. Teacher training workshops for the CUE-TSIPS program have been implemented by the WFP™ program both in Ukraine and in the U.S. Students from U.S. and Ukraine schools have already begun exchanging letters as a result of participation in CUE. The U.S. Embassy in Ukraine and NASA Headquarters are assisting in this exchange by providing an inexpensive way for mail from Kiev to reach the students in the U.S. via pouch-mail carried from Kiev to Washington D. C. and placed into the U.S. Postal System.

Instructional materials development began in November of 1995. CUE experiments were demonstrated to the 1996 Summer Teacher Enhancement Program (STEP) participants at Kennedy Space Center (Dreschel et al., 1995, 1996). The experiments were also presented in CUE workshops implemented in Kiev, Ukraine (October, 1996) and Madison, Wisconsin (March, 1997).

A CUE TSIPS teachers guide became available in early 1997 for participant use. This guide was developed by the WFP™ program and published by the NASA Office of Human Resources and Education, in cooperation with the NASA Space Life Sciences Division. The guide, titled “Teachers and

Students Investigating Plants in Space: A Teacher's Guide with Activities for Life Sciences" contains a detailed description of the construction of "classroom" CUE hardware, as well as procedures for planting, culturing, pollinating, and measuring development in the *Brassica rapa*. In addition, activities centered on plant responses to gravity and light are described which utilize 35 mm film cans and soda bottle caps. There are also activities described which demonstrate the physics of gravity and microgravity (Vogt and Wargo, 1992). The suggested construction of the simulated CUE hardware Plant Growth Chamber (PGC) is shown in Figure 1.

Figure 1: Simulated PGC.



The materials for constructing the PGC are readily available and inexpensive or cost-free. Seed are planted in the wick-pots and in about 16 days, the *Brassica rapa* will be hand-pollinated using a beestick, constructed from the thorax of a honeybee and a toothpick. This is the same activity that will be performed by the Ukrainian PS during the mission. Students (and scientists) will track the success of the pollination and the subsequent development and viability of the seed produced.

The anticipated result of this education component is that the over 40 master teachers that have been trained will each hold a workshop in which at least other 20 teachers will be trained (level 2) and in these over 840 classes, over 20,000 students will participate in the CUE. The teachers guide is targeted for distribution at NASA centers around the country and is available on the WFP™ Home Page on the World Wide Web at http://fastplants.cals.wisc.edu]. Additional information is available on the KSC Biomedical Office, Life Sciences Education Programs Web Page at [http://atlas.ksc.nasa.gov/education/general/educate.html].

In summary, the CUE is investigating selected questions about plant responses to the space environment while involving teachers and students in space life sciences research. The enthusiastic response from scientists, teachers, and students from both the U.S. and Ukraine has been noteworthy and the project has had considerable media coverage in both countries. This enthusiasm will prove to make the CUE a highly successful scientific, educational, and cultural-exchange "mission" for all participants.

Literature Cited

Dreschel, T. W., Young, R., Hodges, J., and Ragsdale, J. 1995. Implementation of a NASA Life Science Teachers Workshop as Part of the Summer Teacher Enhancement Program. Proceedings of The 32nd Annual Space Congress, Cocoa Beach, Florida, pp. 9.1-9.8.

Dreschel, T., Hodges, J., Dutczak, S., and Fronk, R. 1996. Measuring the Concerns and Beliefs of Teachers: A Possible Means for Evaluating the Efficacy of NASA Teacher Enhancement Workshops. Proceedings of The 33rd Annual Space Congress, Cocoa Beach, Florida, pp. 6.1-6.8.

Vogt, G. L. and M. J. Wargo, Eds. 1992. Microgravity. Washington, D. C.: The National Aeronautics and Space Administration.

Williams, P. H. (1995). Exploring with Wisconsin Fast Plants. Dubuque, IA: Kendall/Hunt Publishing Company.

Williams, P. H., Greenler, J., Greenler, R., Graham, L., Ingram, M., Kehle, L., & Eagan, D. (1993). Bottle biology, an idea book for exploring the world through soda bottles and other recyclable materials. Dubuque, IA: Kendall/Hunt Publishing Company.