Space RAD Health Newsletter

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NASA Announces Opportunities for Space Radiation Research

On August 30, 2002 NASA's Office of Biological and Physical Research (OBPR) announced new opportunities for Ground-based Research in Space Radiation Biology and Space Radiation Shielding Materials (NRA 02-OBPR-02). Access to application materials and guidelines for submittal of proposals can be obtained from:

http://research.hq.nasa.gov/code_u/open.cfm

Proposals are due to OBPR on November 25, 2002.

These new grants are anticipated for funding in fiscal year 2003. The focus of the new NASA Research Announcement (NRA) in Space Radiation Biology is to solicit research investigations that will support the first use of the Booster Application Facility (BAF) at Brookhaven National Laboratory in 2003. There are seven areas of research that are emphasized in the NRA:

- **DNA mutagenesis and recombination**: Genetic mutations played a critical role in the evolution of life forms on Earth (and perhaps our universe) and are known to participate in or cause cancer formation. This research component will seek to develop or apply fundamental knowledge of DNA mutagenesis and DNA recombination in order to advance our understanding of the molecular basis for mutation in transcribed and non-transcribed DNA after exposure to space radiation components.
- **Molecular Radiation Biology of Carcinogenesis**: Improving estimates of cancer risks from space radiation using genetic- and molecular-based animal or tissue models, and developing the knowledge needed to use such models to project risks in humans are priority research areas. This research component will seek to understand the molecular mechanisms of carcinogenesis by protons and HZE particles, including the development of new experimental models of radiation-induced cancers. Research whose primary goal is to measure tumor induction by radiation are not being considered at this time.
- **CNS radiobiology**: This topic addresses the development of the understanding needed to estimate the risk of degenerative tissue diseases, especially the short term and long term consequences of central nervous system (CNS) irradiation by HZE particles. General questions to be answered include the following: Are the deleterious effects that are observed in cancer patients receiving high dose gamma irradiation to the CNS observed when rodents are irradiated by HZE particles? What are the cellular and molecular mechanisms of damage to the CNS following irradiation by HZE particles? What morphological changes occur?
- **Individual genetic susceptibility**: This topic addresses individual-based approaches to risk projections, including the understanding of genetic sensitivity and resistance, and the development of molecular markers of carcinogenesis and/or cancer risk that will allow NASA to project the individuals' risk to space radiation.
- **Discovery of biological countermeasures**: This topic addresses the development of molecular understanding and identification of targets for risk assay development and intervention leading to discovery of successful biological countermeasures from space radiation.
- **Novel radiation shielding materials**: This topic addresses the development of novel radiation shielding materials containing light nuclei and hydrogen such as polyethylene and lithium hydride, compounds and absorbing materials containing high atomic ratios of hydrogen, and simulations of planetary regolith material either in raw form or processed for eventual *in situ* use as a construction material. Some of these materials, e.g., carbon nano-materials, metal hydrides, and palladium/silver alloys, are already under study by groups examining renewable and clean energy sources. In the development of novel shielding materials properties enabling multiple functions, possible hazards and their mitigation, and potential ease of manufacture/fabrication and costs must be considered. Proposals for new shielding materials must provide results of radiation transport codes justifying their intended use as an alternative to polyethylene as a minimum standard of shielding performance.
- **Multifunctional spacecraft materials**: Some materials that are not optimum for shielding alone may have a multiple function, such as high strength or hydrogen storage. Multifunctional materials must either be known spacecraft materials or permit substitution for one or more spacecraft materials. Multifunctional materials that are proposed for supplementary shielding must be evaluated for their effectiveness, first by using the radiation transport codes, and then by measurement at particle accelerators.

Space Radiation Health Investigators' Workshop - 2003

The 14th Annual NASA Space Radiation Health Investigators' Workshop is now scheduled for April 27th (Sunday) through April 30th (Wednesday), 2003. The workshop will be held at South Shore Harbour Resort and Conference

Center, League City, Texas.

The scientific committee for the 14th Annual Workshop is: Dr. Francis A. Cucinotta, *NASA Johnson Space Center*; Prof. John F. Dicello, *Johns Hopkins University*; Dr. Amy Kronenberg, *Lawrence Berkeley National Laboratory*; Dr. Greg D. Nelson, *Loma Linda University Medical Center*; Dr. Walter Schimmerling, *NASA Headquarters*; Dr. Michael D. Story, *University of Texas M. D. Anderson Cancer Center*; Dr. Betsy M. Sutherland, *Brookhaven National Laboratories*; and Dr. Elizabeth L. Travis, *University of Texas M. D. Anderson Cancer Center*. As the scientific committee finalizes the program schedule and other details, more information will be made available via the SRHP Website.

2002 NASA Radiation Health Research Grants - Awarded

NASA's Office of Biological and Physical Research (OBPR) has awarded four new research grants that will support the health and safety concerns for future human space flight in the area of radiation damage to biological systems. The four research grants were awarded to Dr. Aloke Chatterjee of Lawrence Berkeley National Laboratory, Dr. Lora Green of Loma Linda University, Dr. James Reuben of the University of Texas M.D. Anderson Cancer Research Center, and Dr. Bjorn Rydberg of Lawrence Berkeley National Laboratory.

Critical Path Roadmap in Space Radiation Health Research

A useful guide for research proposals is the OBPR Bioastronautics Programs Critical Path Roadmap, which supports research in the life sciences aimed at the human exploration of space. The Critical Path Roadmap Mission Statement is

- To communicate the objectives for the human exploration of space and the progress towards those objectives.
- To provide an integrated, cross-discipline strategy to assess, understand, mitigate, and manage the risks associated with long-term exposure to the space environment.
- To target the direction of research and technology development for long-duration, human space exploration.

Figure 1 shows the current CPR in the area of Space Radiation Health. In support of the CPR for each life science area, Critical Questions for research and technology efforts needed to further assess the risk and address its mitigation have been developed. The current CPR in Space Radiation Health can be viewed on-line at http://bioastroroadmap.nasa.gov/User/discipline.jsp?filterDisciplines=11.

Each radiation risk has an associated set of core questions. The current Critical Questions in radiation are:

- Are there unique biological effects associated with high charge and energy (HZE) ions?
- What is the acceptable accuracy for risks of acute and late effects in humans from photons to adequately extrapolate to space?
- How can animal and cell experiments be done and data best be used to extrapolate to the human risk from space radiation?
- What are the risks from SPE's and what is their impact on operations, space-walks and surface exploration?
- How do the thickness, design, and material composition of space vehicles affect the internal radiation environment and biological assessment?
- Do we have strategies for calculating risks that are adequate if expected data are provided and what are uncertainties?
- Are there differences in response to particles with similar LET, but with different atomic numbers and energies?
- What are the effects of age, gender, and inter-individual diversity?
- Are the biological effects for protons above 10 MeV sufficiently similar to photons that photon data can be used for their consequences?
- Are there chemo-preventive or biological agents which would mitigate acute or late effects?

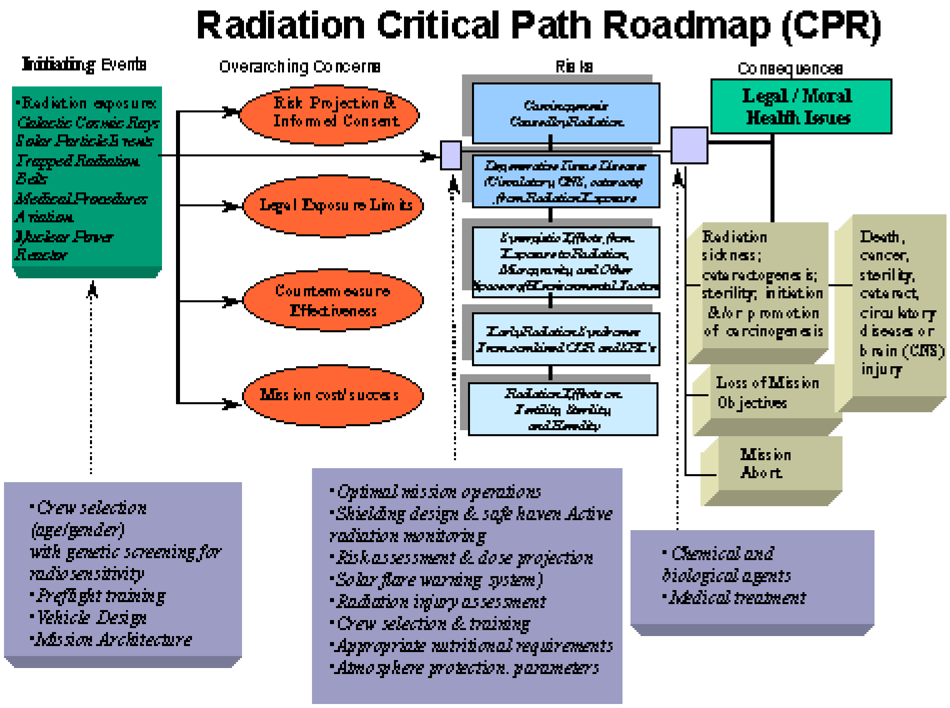

Figure 1. Critical Path Roadmap for Space Radiation Health Research.
(Click on image for larger view.)

As researchers make progress including scientific breakthroughs, it is important to revise the Critical Questions related to each risk area. In 2003 a revision of the CPR questions in radiation is expected to occur and will be reviewed at the 14th Annual Space Radiation Health Investigators Meeting. Suggestions for CPR questions can be emailed to the SRHP Web site.

Radiation Shielding on the International Space Station: Topology and Material Selection

Are traditional approaches to radiation shielding effective against space radiation? NASA researchers have identified some key differences including in the areas of material selection and topology, which are leading to improvements for ISS and new design processes for exploration. Figure 2 shows the application of CAD models of the ISS to project the amounts of shielding received by astronauts during space walks including detailed models of the shielding provided by the space suit and human body. The use of improved hydrogen-rich materials such as polyethylene or water reduce the GCR (including secondary radiation such as neutrons) dose equivalent by 20-30% and by a larger amount for trapped protons and solar particle events. However, practical amounts of any material is limited in how much dose reduction can be acheived from the highly penetrating GCR. A second approach for reducing space radiation effects on ISS is to optimize topology. Here since astronauts spend over one-half of their day in common areas such as the sleep stations, galley, and exercise areas, insuring the optimal topology for common areas provide a significant benefit.

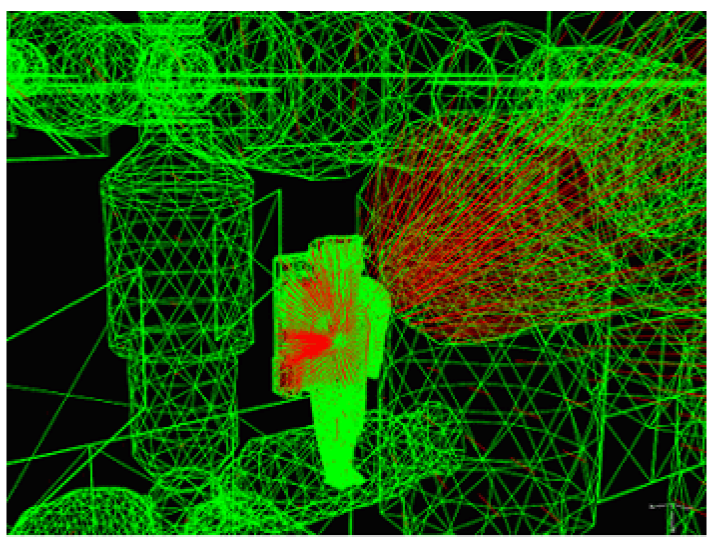

Figure 2. Shielding provided by the ISS to astronauts during space walks as predicted by the NASA Langley Research Center and Johnson Space Center collaboration on ISS shielding models.

Figure 3 shows measurements by the Space Radiation Analysis Group (SRAG) at Johnson Space Center from the first four ISS Increments that illustrate the variations in dose due to topology. A range of variation >50% is observed. Critical issues in understanding variations inside spacecraft are the directionality issues related to source particles such as the trapped particles pitch angle distribution and the role of the Earth's shadow on GCR exposures, as well as the variation caused by the vehicle geometry.

These results suggest that the combined use of optimal shielding materials and the topology of common areas will be the most effective method to reduce radiation exposures in space in the future. Data and methods developed for the ISS is providing valuable lessons and insights for the design of future spacecraft exploring the moon or Mars.

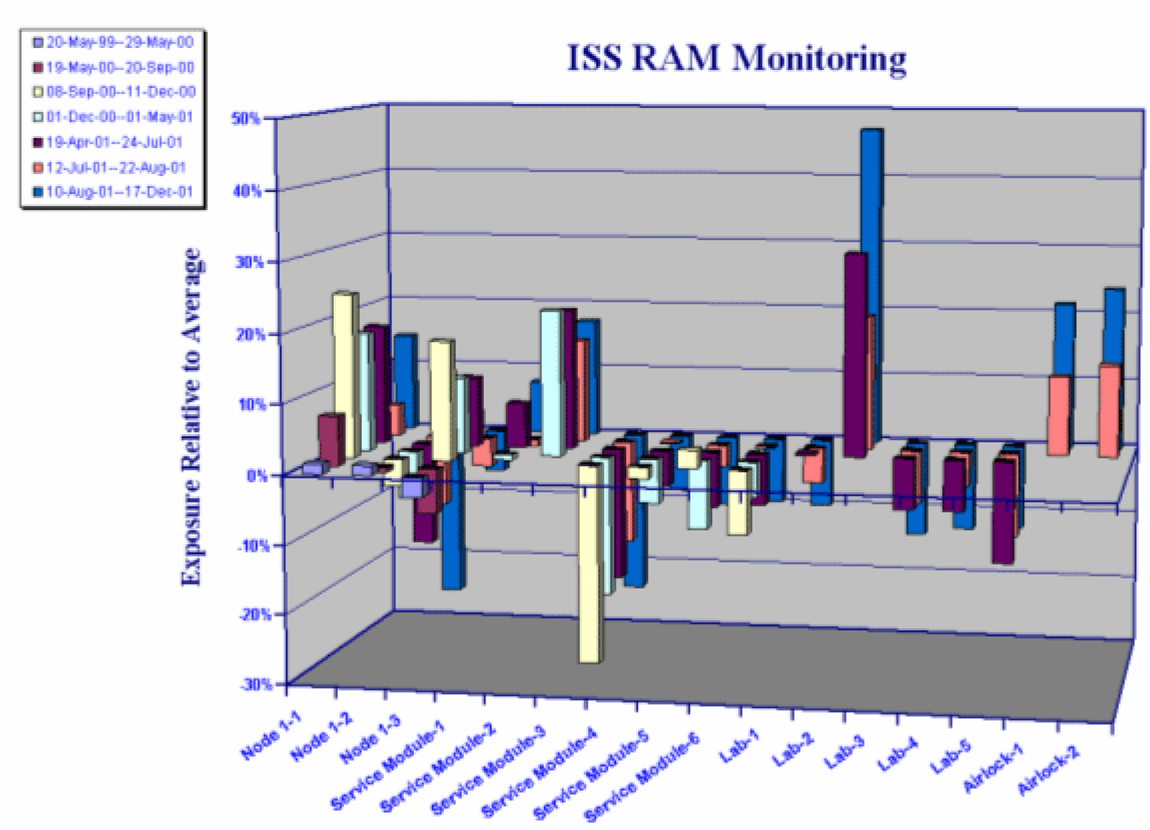

Figure 3. Measurements of absorbed doses on the ISS at JSC for early ISS increments.
(Click on image for larger view.)

MARIE Updates Solar Particle Events on the Far Side of the Sun

The Martian Radiation Environment Experiment (MARIE) continues to provide valuable data on the space radiation environment at Mars. The MARIE experiment is a NASA JSC experiment, led by Dr. Cary Zeitlin, Principle Investigator from the NSBRI, and Lawrence Berkeley National Laboratory. In recent months, MARIE has observed several Solar Particle Events (SPE) including ones from the far side of the Sun. During April 25th, Mars and Earth were 106 degrees apart with respect to Sun, and the solar disk that is visible from the Mars is different from the one that is visible from earth. Figure 4 shows the increase in dose-rate at Mars measured by MARIE from the SPE of April 25, 2002.

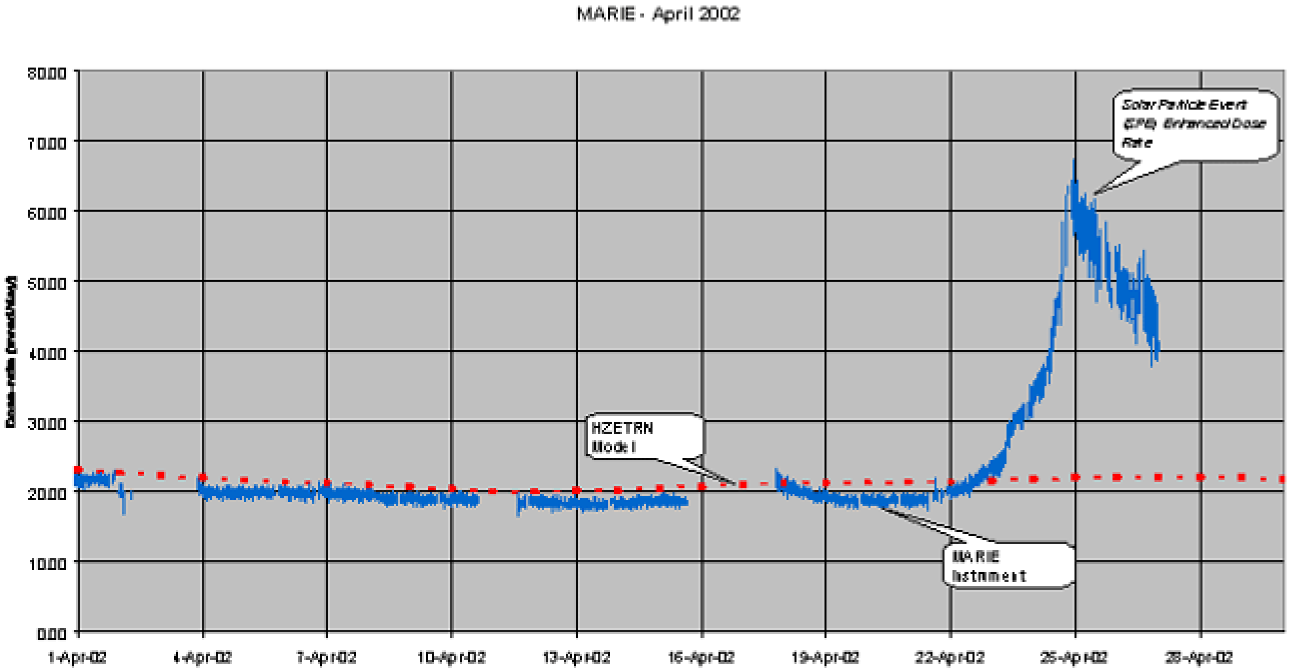

Figure 4: Preliminary dose-rate measurements from the MARIE instrument in Mars orbit from April 2002. A threefold enhancement from the normal background GCR dose-rate was noticed during April 25th due to a SPE. The blue line (discrete) is the measured data by the instrument and the red (dotted) line is the model predictions for April 2002. MARIE instrument data and the HZETRN model calculations using the Badhwar and O'Neill GCR environmental model are very closely correlated (within 10%).

The MARIE team has been developing procedures and algorithms to make predictions of the solar disk activities on the far side of the Sun. Data from the SOHO spacecraft are mapped to 3D views of the Sun and the solar disk that is visible from Mars is obtained to identify the solar activity that is likely to have connection to Mars. Images of the solar disks for April 25th are shown in Figure 5. On August 11, 2002, the Earth, Sun, and Mars were in conjunction with Mars opposite to the Sun with respect to the Earth. The opportunity to collect data on SPE's in this exciting period of Mars-Earth phasing relative to the Sun should prove valuable in preparing for future human exploration plans.

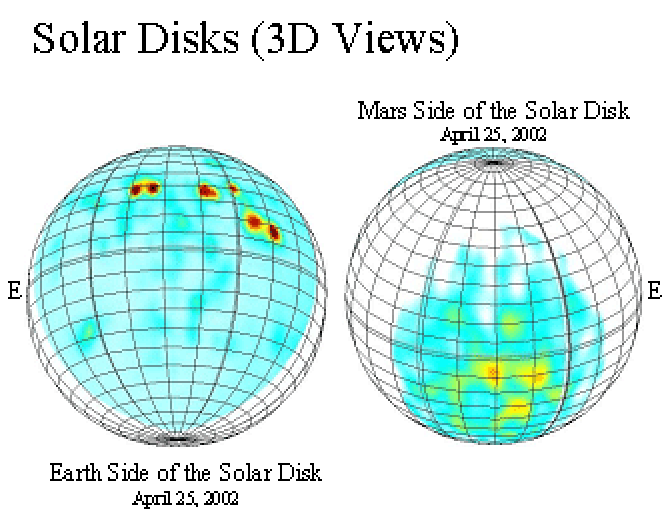

Figure 5: The Solar disk visible from Earth is shown in the left panel with active regions mostly in the northern hemisphere of the Sun. The solar disk that is visible from Mars is shown on the right panel with active regions mostly in the southern hemisphere. The view of the solar disk that is visible from Mars is about 106º off from the Earth's side of the solar disk.

SRHP Featured Investigator: John F. Dicello, Ph. D.

	John F. Dicello, Ph. D. Professor of Oncology

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Baltimore, MD 21231

Dr. Dicello has been with Johns Hopkins University School of Medicine as Professor of Oncology in the Division of Radiation Oncology since 1995. Prior appointments of Dr. Dicello include: professor of physics with Clarkson University, NY (1982-1995); teaching faculty with the University of New Mexico - Los Alamos, NM, Campus (1981-1982); research scientist in the biomedical group with the Los Alamos National Laboratory of the University of California (1973-1982); and faculty member with the College of Physicians & Surgeons of Columbia University, NY (1967-1973). Dr. Dicello received his B.S. degree in Physics from St. Bonaventure University, NY (1960), M.S. degree in Physics from the University of Pittsburgh, PA (1962), and Ph. D. degree from the Texas A&M University in Physics (1968).

Dr. Dicello has been involved in three research areas: radiation therapy, cancer research, and microdosimetry. He began his career in medical physics at Columbia College of Physicians and Surgeons shortly after completing his Ph. D. at Columbia University. Dr. Dicello was as member of the group under the direction of Prof. H. H. Rossi credited with developing the field of microdosimetry. Microdosimetry is the study of energy transfers in matter at micro and sub micrometer levels, and it has found major applications in radiation biophysics and electronics. Dr. Dicello was one of the first researchers to recognize that significant errors in microelectronics were being produced because of microdosimetric effects and was subsequently funded by the Air Force to examine error rates in microelectronics from environmental mesons. He served as a principal investigator for a subcontract from an NIH (National Institute of Health) and AAPM (American Association of Physicists in Medicine) supported dosimetric inter-comparison among research institutions engaged in human trials using protons and heavier ions for radiation therapy. Dr. Dicello was the member of the team at Columbia that was responsible for the first dosimetric and biological measurements of the therapeutic potential of energetic heavy ions. Also, he served as a member of the biomedical group at the Los Alamos National Laboratory (LANL) that carried out first human studies with energetic pion beams. Dr. Dicello served as a consultant to the Loma Linda University for the design and construction of the first clinical based proton therapy facility and collaborated with Fermi National Laboratory for the pre-clinical data to design its neutron therapy facility.

Apart from his teaching, research, and executive responsibilities with the Johns Hopkins University School of Medicine, Dr. Dicello has been contributing to the radiation community as a:

- Council Member, National Council on Radiation Protection & Measurements, Bethesda, MD (2000)
- Team Leader, Radiation Effects, National Space Biomedical Research Institute, Houston, TX (since 1997)
- Member, Commission F (Life Sciences), Intl. Committee on Space Research, COSPAR (since 1994)
- Associate Editor of the Radiation Research, an International Journal (1992-1996)
- Member of the Task Group for Radiation Hazards to Crews of Interplanetary Missions (1996) of the National Academy of Sciences; National Research Council (NRC); and NRC Board on Assessment of National Institute of Standards and Technology (NIST) Programs (2001)

Prof. Dicello is currently the Leader of the Radiation-Effects Team of the National Space Biomedical Research Institute (NSBRI), Baylor College of Medicine - Houston, Texas. The research of this team presently includes six projects:

- Studying cancers occurring in rodents after low-dose exposures to high-energy iron ions, protons or photons (Dr. Dicello, Principal Investigator)
- Testing non-toxic drugs as a means to reduce the risks of cancers or damage to the central nervous system; (Dr. David Huso, Johns Hopkins University, Principal Investigator).
- Identifying dietary supplements which may be most effective at reducing levels of oxidative stress and cancer risks; (Dr. Ann Kennedy, University of Pennsylvania, Principal Investigator)
- Analyzing how various types of radiation affect central nervous system cells (Dr. Marcelo Vazquez, Brookhaven National Laboratory, Principal Investigator); and
- Testing ways to modify brain-cell response to radiations and testing several compounds as potential countermeasures, (Dr. Marcelo Vazquez, Brookhaven National Laboratory, Principal Investigator)
- Evaluating alterations in the genome using the *lacZ* transgenic mouse model, the only system available, to date, for the assessment of alterations in the genome in every animal tissue (Dr. Polly Chang, SRI, Principal Investigator).

Prof. Dicello comments on his current research investigations that - *"During extended space travel, humans, particularly those going to Mars, are continuously exposed to unusual and intense radiation fields. As a result, there is the possibility of biological*

consequences. Our research investigations focus on evaluating the health risks from these radiation particles. Once we establish those risks adequately, we may be able to develop better physical countermeasures such as structural changes to the spacecraft to reduce the radiation levels to the astronauts. Finally, we hope to find pharmaceutical approaches to reduce the risk from these radiation exposures."

Selected Research Publications

- F. A. Cucinotta, J. F. Dicello, H. Nikjoo, and R. Cherubini, "Computational model of the modulation of gene expression following DNA damage." Radiat. Prot. Dosimetry 99, 85-90 (2002).
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Selected Protocol

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