The Boice Report #46

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Mars Matters!

Kristina Rex interviews astronaut Jessica Meir in recognition of the anniversary of the Challenger disaster.
Photo courtesy of Jackson Grimm, WLBZ-TV NBC in Bangor, Maine

There are certain times in our lives when an event is indelibly etched into our collective memories. We know exactly where we were when the event occurred. For me there have been several: in 1963 when President John F. Kennedy was assassinated, in 2001 when the Twin Towers collapsed during the terrorist attack, and in 1986 when the Challenger space shuttle exploded shortly after takeoff. This past month marked the 30th anniversary of the Challenger disaster and my niece, Kristina Rex, interviewed astronaut Jessica Meir, in Bangor, Maine, in remembrance of the valiant astronauts who died suddenly in our collective quest to explore and understand the universe we live in. Jessica Meir came from a small town in Maine, earned a doctorate in marine biology, became an astronaut, and continues to inspire young people as a role model, exemplifying the American spirit of achieving your dreams no matter the circumstances!

The MPS relevance to NASA. The National Aeronautics and Space Administration (NASA) supports the research for the Million Person Study (MPS)—it will provide a more representative group (healthy American men and women) for risk estimates than the 1945 Japanese population exposed in a fraction of a second to the atomic bombs, risk estimates will be more precise because the adult population is 20 times larger and there are many more high-dose subjects (>100 mSv), differences between men and women in their response to radiation can be more fully examined, and noncancer outcomes such as neurological disorders and cardiovascular disease can be evaluated in a way not hitherto possible. NASA uses a risk-based system for radiation protection in contrast to the system of dose limits for occupational exposures used by terrestrial-based organizations. The permissible career exposure limit set by NASA for each astronaut is a 3% risk of exposure-induced death (REID) from cancer at a 95% confidence level to account for uncertainties in risk projections (NASA 2016). MPS will reduce the uncertainty in the risk estimates, which might allow more time in space for astronauts.

Sex Matters! Based on the Japanese atomic bomb data, women are about two times more sensitive to radiation than men on a relative scale, due in part, but not entirely, to the differences in the sensitivity of the sex organs, i.e., cancer of the female breast and ovaries are increased after radiation exposure, whereas cancer of the testes and prostate are not. This difference limits the time female astronauts can spend in space as well as their potential departure on long-term missions such as to Mars. The Japanese data, however, include children and the elderly and are based on small numbers, only about 30,000 adult women and about 21,000 adult males. The MPS has 250,000 adult women under study so that precise comparisons with the 750,000 adult males in the study are possible. We've just embarked on a new study of 21,000 female workers who worked from 1943 to 1947 at the Tennessee Eastman Corporation in Oak Ridge. These women have never been studied and are mentioned in the recent best-selling novel *The Girls of Atomic City*. They worked in the facility that eventually became known as Y-12 and many operated the 1,152 Calutrons, i.e., mass spectrometers that used electromagnetic fields to separate ^{235}U from natural uranium for the World War II effort (specifically for the “Little Boy” weapon dropped on Hiroshima). A more precise determination of sex-specific cancer risk might allow more time in space for female astronauts.

The Brain Matters! NASA is particularly interested in behavioral and cognitive impairments due to effects of space irradiation on the central nervous system (CNS), including those of high-velocity heavy ions (e.g., 56Fe) zipping through space like cosmic bullets emanating from the explosion of a supernova. There are animal studies showing detrimental early and late effects of space irradiation on behavioral and cognitive performance as well as measures related to plasticity and inflammation in the brain. There is no real analog of human studies that can approximate these heavy ion exposures. However, the unique population of workers at the Mound facility (and also at Rocketdyne) had intakes of polonium, an alpha-particle emitter. Polonium differs from all other internal alpha-particle emitters in that it goes to all soft tissues, including the brain, and not primarily bone. Five large studies within the MPS are now being combined to look at dementia, Alzheimer's, Parkinson's, and motor neuron disease to learn whether exposures, at least to low linear-energy-transfer radiation, might be linked to increases of these conditions.

John Boice training for Mars Photo courtesy of Suzanna Rosi, UCSF

NASA Matters! I spent a week in Galveston, Texas, for the second year in a row attending the Human Research Program of NASA. Tried to hitch a ride to the International Space Station—hey, John Glenn was 77—but no luck! It is an extraordinary experience to be exposed to the wide range of ongoing activities to support our astronauts traveling to space. Radiation is just one of many elements needing to be considered in this life-threatening activity. To provide guidance on the possible CNS effects from space radiation, NCRP recently prepared a commentary (No. 25) for NASA that will be published within the next few months.

NCRP Matters! The CNS commentary led to a new committee that will prepare a more comprehensive report than was possible in the commentary. Scientific Committee 1-24 (Phase 2) met for the first time after the NASA workshops. Some questions to be addressed:

- How should a "significant impairment" in performance be defined?
- How might space radiation "interact" with other aspects of a mission that would impair performance, both for the individual and the team, such as sleep deprivation, medications, zero gravity, constant close quarters, reduced communications, and absence of windows to the world?
- What is the relative balance between the likelihood of neurobehavior effects that would impair operational performance and adversely affect the mission, and what is the likelihood that serious neurodegenerative diseases develop such as Alzheimer's, Parkinson's, Huntington's, amyotrophic lateral sclerosis, and dementia?
- True to all human tissues, the brain is designed to respond rapidly to changes and then compensate for survival. Do compensation mechanisms exist that would influence the likelihood of getting to a level of significant impairment that would adversely affect performance and the mission?

The vision for humankind and space exploration is epitomized by Elon Musk, who said that he would like to die on Mars, but not on impact! Let's work to prevent the latter!

SC 1-24 in Galveston, February 2016: left to right, Larry Townsend (University of Tennessee, NCRP staff consultant), Greg Nelson (NASA, Loma Linda, observer), John Hopewell (Oxford), Kerry O'Banion (University of Rochester), "Q" Qin (Naval Submarine Medical Research Laboratory), Peter Winsauer (Louisiana State University), Dudley Goodhead (Medical Research Council, U.K., emeritus), Kevin Krull (St. Jude), Jacob Raber (vice chair, Oregon Health and Science University), Les Braby (chair, Texas A&M). Not in photo: Polly Chang (SRI International), David Dinges (University of Pennsylvania), David Herr (Environmental Protection Agency), Tom MacVittie (University of Maryland), James Root (Memorial Sloan Kettering), Susanna Rosi (University of California, San Francisco), Janice Huff (NASA, observer) Photo courtesy of John Boice, NCRP