Critical Questions

Critical radiation hazards for humans in space

- What are the factors that determine radiation flux of solar flares?
- What are the maximum flux, the integrated fluence, and the probability of large Solar Particle Events (SPE) during any mission?
- What are the doses related to heavy ions in deep space?
- How can protection against the effects of galactic cosmic rays and the proton radiation of solar events be improved?
- What should be the radiation dose limits for manned deep space missions?
- What is the relative biological effectiveness of different types of radiation for the relevant endpoints such as cancer; cataracts?
- What is the probability of cancer as a function of dose, dose rate, radiation quality, gender, age at exposure and time after exposure? What is the effect of GCR at different stages of the carcinogenesis process?
- What is the probability of cataract formation as a function of the same quantities?
- What is the probability for genetic and developmental detriment incurred as a consequence of radiation exposure in space?
- How are risks associated with acute exposure to space radiation to be managed medically?

Complex radiation fields

- What Is the solar cycle dependence of space radiation? What is the trapped radiation flux as a function of time, magnetic field coordinates and geographical coordinates?
- For a given mission, what are the fluxes of GCR in interplanetary space as a function of particle energy, LET and solar cycle?
- What will the radiation environment be within the space vehicle and what factors influence the flux, energy, and linear energy transfer spectra of the radiation?
- What are the cross sections and yields for nuclear interactions of HZE particles in tissue and shielding materials?
- What are the angular distributions of nuclear interaction products? What are the particle multiplicities of nuclear interaction products?
- How is a radiation field transformed as a function of depth in different materials?
- What are the optimal ways of calculating the transport of radiation through materials?

Mechanisms of radiation action

- How is physical energy deposition related to biological effect?
- What are the yields and energy spectra of electrons?
- What is the precise energy deposition of heavy ions?
- How can the wealth of knowledge existing for energy deposition in gaseous media be extended to the liquid phase applicable to most living cells?
- How do diffusion, recombination and other interactions of chemical intermediaries alter the chemical events at the DNA level?
- Could a single particle take out a multiple stem cell ?

- Can unique effects (like totally exploded chromosomes) be produced with low probability by some HZE particles?

Radiation response: molecules to cells

- How are processes like oncogene activation and oncogene suppressor inactivation involved in the carcinogenic effects of GCR radiation?
- How can molecular mechanisms of radiation damage be used to understand effects in whole cells?
- What mechanisms are involved in modulating radiation damage at the molecular level (repair, errors in repair, gene amplification, etc.)?
- What are the probabilities of GCR to produce radiation damage at specific sites on DNA?
- What is the nature of genomic instability caused by heavy charged particle radiation?
- What are the sizes of molecular lesions relative to functional units on DNA, as a function of ionization density?
- Can early molecular changes be use to predict probability of subsequent carcinogenic effects?

Radiation response: cells to humans

- What is the probability of initiating neoplastic cell transformation or other stages leading to a cancerous cell?
- How do cellular repair mechanisms modulate damage produced by energetic charged particles?
- How can the radiation effects on cells in culture be related to radiation effects in "normal" cells and tissues?
- How can animal models be used to extrapolate probabilities of radiation risk to humans in space?
- What pharmacological agents should be developed and tested as prophylactic agents for low LET?