Inspiration Mars
Crew Health and Safety Concerns

Taber MacCallum
Graham Scott, Ph.D.
Ann R. Kennedy, D.Sc.
Jonathan Clark M.D., M.P.H.

Humans 2 Mars Summit
May 6-8, 2013 - George Washington University
Approach to Crew Health and Safety

• The prowess of American academic medicine and life sciences will be harnessed to address the Inspiration Mars crew health
• Primary Approach: Pre-mission phase (crew selection, prevention, health screening, prelaunch crew optimization)
• Secondary Approach: In-flight countermeasures to reduce or delay the degrading effect of the mission or environment
• Tertiary Approach: In-flight Diagnosis and Treatment of a condition that has developed
Key Inspiration Mars Approach

• “Abort to Earth” is not feasible
• Advanced medical care systems should focus on mission performance, less on post mission health, which can be managed back on Earth
• Pre-mission health optimization will be used to the maximum extent possible
• Personalized Medicine Program (using genomics/proteomics) will be used to individualize therapeutic and preventive measures based on environmental and genetic risk factors
Astro-Omics

• Personalized Genomic Medicine for astronauts to better safeguard long duration exploration missions utilizing a systems biology approach

• Personalized genomic medicine is a 21st century strategy for risk mitigation during long duration deep space missions

• To fly to Mars and return safely to Earth we need to employ the full power of 21st century Earth based medicine

• Countermeasure Applications
  o Pharmaco-astro-genomics
  o Omics based interventions to mitigate radiation effects Astronauts exhibit “personal” responses to space radiation
  o Optimizing sleep and circadian rhythms for astronauts
  o Develop disease susceptibility assay(s) & personalized mitigation approaches
Personalized Medicine For Astronauts

Radiation Effects
Can we use –omics technologies to monitor the effects of space radiation on the molecular physiology of individual astronauts?

Pharmacogenomics
Can we select efficacious drugs with minimal adverse effects for individual astronauts?

Visual Impairment – Intracranial Pressure
Why do some astronauts experience visual impairment and others not?

Neurobehavioral Factors
Can we personalize sleep countermeasures for individual astronauts?
Basner, M. et al., Mars 520 d mission simulation reveals protracted crew hypokinesis and alterations of sleep duration and timing”, PNAS, (2013), Feb 12, 110(7), 2635-40
Personalized Medicine Strategy For Inspiration Mars

Candidate Selection
- Accelerate existing astro-omics based research
- Undertake comprehensive -omics analysis of candidates

Candidate Training
- Implement targeted -omics based analysis of candidates
- Design mission specific -omics based countermeasures
- Test mission specific -omics based countermeasures

Flight
- Operationally deploy personalized medicine based countermeasures
- Develop personalized based countermeasures for unanticipated medical contingencies “on-the-fly” using data already collected

Post-Mission
- Monitor astronauts following return to Earth using -omics based medicine
- Detect cancer/other diseases early

Candidate Selection

Candidate Training

Flight

Post-Mission
Space Radiation Environment
Space Radiation Types

• High dose-rate Solar Particle Events
  o medium to high-energy protons
  o occur during maximum solar activity
  o cause acute radiation sickness

• Low dose-rate Galactic Cosmic Radiation, solar wind
  o Protons, Gamma rays, high energy heavy particles (HZE) and secondary radiation
  o Neurologic and cardiovascular deficits, cancer
  o Combined with microgravity effects
  o Largest doses occur during minimum solar activity in an 11-year solar cycle
Radiation Risk Reduction Strategies

- Vehicle shielding design requirements
- Active and passive personnel dosimetry
- Real time space weather monitoring
  - Monitoring Heliosphere for impending SPE
  - SPE forecasting methods
- Crew training for contingency procedures that minimize radiation risk during SPE
- Rapidly deployable polyurethane shielding crew radiation shelter during SPEs
- The use of novel radioprotectants and treatment strategies to reduce performance effects that can follow an exposure to large SPE doses.
- Dietary neutraceutical agents to reduce reactive oxygen species
Radiation Environment Risk Assessment

• Mission occurs during solar minimum
• Expert consensus: risk is manageable

Risk of Exposure-Induced Death
500-d Mars Flyby (GCR + SPEprob)

• Multiple dose mitigation strategies can be used to reduce the risk
  o Upper stage & propellant residuals
  o Water storage placement
  o Crew selection
  o Dietary/pharmaceuticals
Psychological and Behavioral Health
Inspiration Mars Medical Team

- Interdisciplinary Team including Academic, Industry, and Government representation
- Specific Focus on Radiation, Microgravity and Behavioral Health Threats utilizing Personalized Medicine Astro-omics Approach
- Tiered Approach involving candidate selection, crew training, as well as mission and post mission support utilizing the highest level of advanced health care delivery