Active Project (2015 - 2015)

Prototype Biology-Based Radiation Risk Module Project

Center Independent Research & Developments: JSC IRAD Program | Mission Support Directorate (MSD)

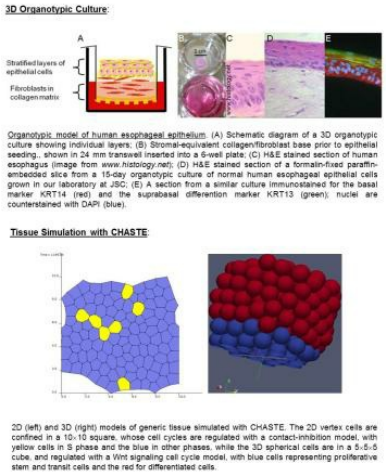
ABSTRACT

Biological effects of space radiation and risk mitigation are strategic knowledge gaps for the Evolvable Mars Campaign. The current epidemiology-based NASA Space Cancer Risk (NSCR) model contains large uncertainties (HAT #6.5a) due to lack of information on the radiobiology of galactic cosmic rays (GCR) and lack of human data. The use of experimental models that most accurately replicate the response of human tissues is critical for precision in risk projections. Our propopsed study will compare DNA damage, histological, and cell kinetic parameters after irradiation in normal 2D human cells versus 3D tissue models, and it will use a multi-scale computational model (CHASTE) to investigate various biological processes that may contribute to carcinogenesis, including radiation-induced cellular signaling pathways. This cross-disciplinary work, with biological validation of an evolvable mathematical computational model, will help reduce uncertainties within NSCR and aid risk mitigation for radiation-induced carcinogenesis.

ANTICIPATED BENEFITS

To NASA unfunded & planned missions:

Space radiation effects and radiation risk mitigation are strategic knowledge gaps for the Evolvable Mars Campaign and are major limiting risks as defined by NASA's Human System Risk Board. Current radiation cancer risk estimates (NSCR) are associated with large uncertainties and there is a need for accurate biological models that can be used to characterize molecular mechanisms of radiation carcinogenesis (HAT #6.5a: Human GCR Radiation Protection). Our proposed work will help reduce uncertainties and mitigate the risk of radiation carcinogenesis by providing a prototype of a biology-based computational model for use along with the NSCR to generate an evolvable cancer risk assessment model. The use of novel



Here are examples of the 3-D tissue cultures we will use to generate biological datasets for this project, and a tissue simulation with the software CHASTE.

Table of Contents

Prototype Biology-Based Radiation Risk Module Project

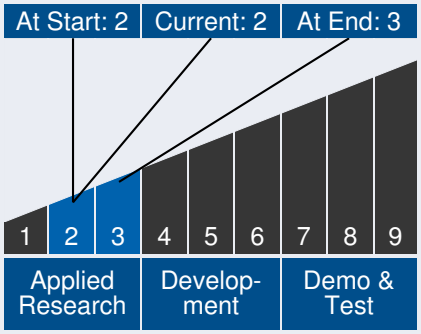
Center Independent Research & Developments: JSC IRAD Program | Mission Support Directorate (MSD)

3D models will also provide a low-cost avenue for testing nutritional and biomedical countermeaures, thereby providing risk mitigation strategies and enabling sustainable human exploration on planetary and other missions.

DETAILED DESCRIPTION

We will utilize novel 3D models as ground testbeds for radiation effects in humans. We will compare radiation effects on normal human epithelial cells in standard 2D monolayer culture with 3D organotypic models in which morphological features, differentiation markers, and growth characteristics of a fully differentiated normal human tissue are more accurately represented. Markers of genotoxic damage and limited histological and cell kinetic parameters will be entered into a multiscale computational software CHASTE (Cancer, Heart And Soft-Tissue Environment) to simulate the tissue homeostasis and radiation response. Comparison of the results (population kinetics and proliferation indices) with the experimental results will provide a biological validation of the CHASTE model; we will formulate quantitative correlations between tissue specific parameters and the outcome of genotoxic effects.

Technology Maturity



Management Team

Program Director:
- Douglas Terrier

Program Executive:
- Douglas Terrier

Program Manager:
- Ronald G Clayton

Project Manager:
- Zarana Patel

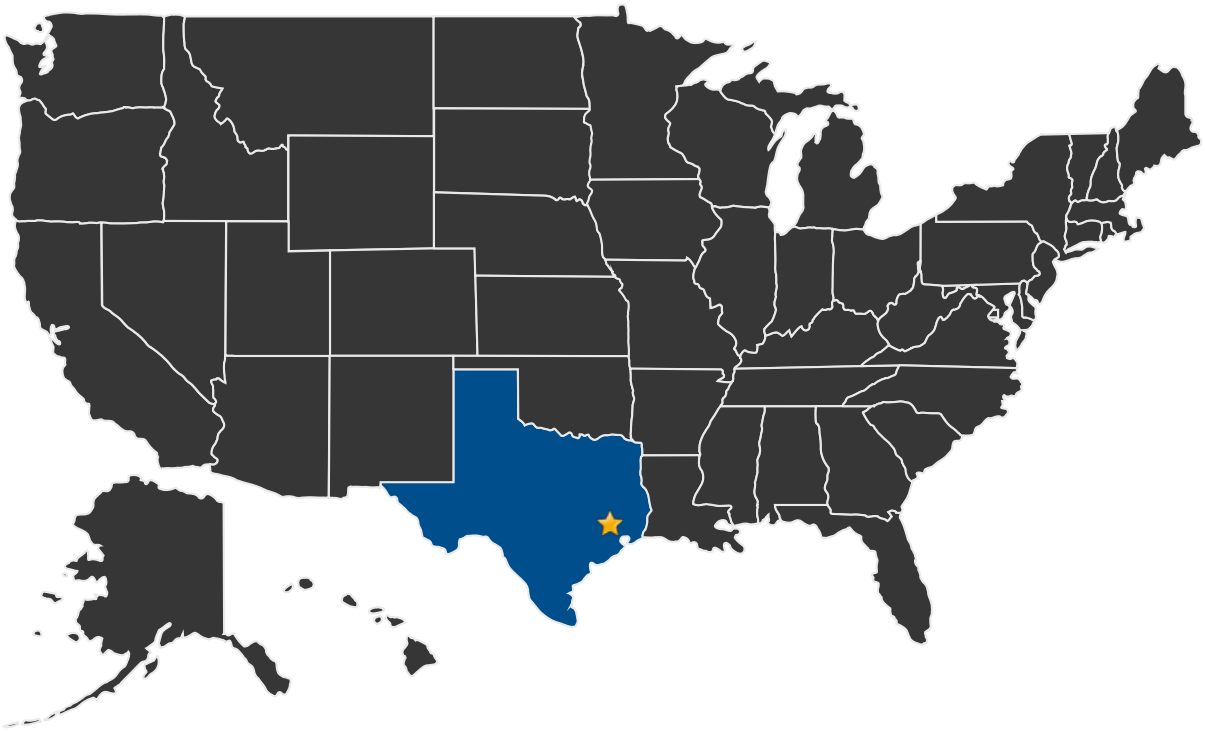
Principal Investigator:
- Zarana Patel

Co-Investigators:
- Shaowen Hu
- Janice Huff

Prototype Biology-Based Radiation Risk Module Project

Center Independent Research & Developments: JSC IRAD Program | Mission Support Directorate (MSD)

U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Johnson Space Center

Other Organizations Performing Work:

- Universities Space Research Association Division of Life Sciences
- WYLE Integration Science & Engineering

Prototype Biology-Based Radiation Risk Module Project

DETAILS FOR TECHNOLOGY 1

Technology Title

Biology-Based Radiation Risk Assessment Module

Technology Description

This technology is categorized as complex electronics software for ground scientific research or analysis

We will utilize novel 3D models as ground testbeds for radiation effects in humans. We will compare radiation effects on normal human epithelial cells in standard 2D monolayer culture with 3D organotypic models in which morphological features, differentiation markers, and growth characteristics of a fully differentiated normal human tissue are more accurately represented. Markers of genotoxic damage and limited histological and cell kinetic parameters will be entered into a multiscale computational software CHASTE (Cancer, Heart And Soft-Tissue Environment) to simulate the tissue homeostasis and radiation response. Comparison of the results (population kinetics and proliferation indices) with the experimental results will provide a biological validation of the CHASTE model; we will formulate quantitative correlations between tissue specific parameters and the outcome of genotoxic effects.

Capabilities Provided

The prototype module will provide a biologically validated radiation risk assessment tool that can be used in conjunction with the epidiomiology-based NASA Space Cancer Risk (NSCR) Model. This will help to reduce uncertainties within the NSCR.

Potential Applications

A potential application for this technology includes being used operationally, with the NASA Space Cancer Risk Model, to predict "Safe Days" for astronauts. Another application includes being used a tool for ground-based scientific research on radiation risks.