Nicholas Myers

Effect of Lunar Dust Simulant on Human Epithelial Cell Lines

Antony S. Jeevarajan, Ph.D./William T. Wallace, Ph.D.

JOHNSON SPACE CENTER

Intoduction/Abstract

The purpose of this project is to assess the potential toxicity of lunar dust to cause the release of pro-inflammatory cytokines by human lung cells. Some of this dust is on the scale of 1-2 micrometers and could enter the lungs when astronauts track dust into the habitat and inhale it. This could be a serious problem as NASA plans on going back to the moon for an extended period of time. Literature shows that quartz, which has a known cytoxicity, can cause acute cases of silicosis within 6 months, and in most cases cause silicosis after 3 years. The activation of lunar dust through impacts creates surface based radicals which, upon contact with water create hydroxl radicals and peroxyl radicals which are very reactive and potentially might even be as cytotoxic as quartz. We can assess the relative cytotoxicity by measuring the amount of cytokines, such as IL-6, IL-8 and TNF-α, in media. So far we have shown that ground quartz has a large cytotoxicity that is generally concentration and time dependent in BEAS-2B cells, but there was no significant cytotoxicity in A549 cells. Lunar simulant showed no significant increase in cytotoxicity in ground or unground dust in BEAS-2B (bronchial) and A549 (alveolar) cells.

There are also additional components to this project such as determining the pathways used in the release of cytokines after dust exposure, imaging the cells to see if dust is being internalized into the epithelial cell, and testing the cells in a microgravity environment to see if the 3-d conformation of the epithelial cells and microgravity simulation would change the cytotokine release. Based on research done on quartz, we believe that cytokine release utilizes three pathways: ERK1/2, p38, and src family kinase. By running Western blots to test for the phosphorylation of these pathways we will be

able to tell which pathways are being used, and if it is similar to quartz, our positive control. It has also been proposed that an internalization of the dust might cause the cytotoxic effect and possibly an apoptosis of the cells. By looking at the cells underneath an imaging microscope we can add the dust to the cells and watch to see if an internalization event happens. We can also do a viability assay to determine if the cells are dying. By growing our epithelial cells in a bioreactor we will be able to mimic the conditions astronauts will be exposed to when they are introduced to lunar dust. We believe that the bioreactors are a better analog for the cells than growing them on a 2-d 1 G plate (we are still using this as a control).

Goals and Purpose of the Project:

As NASA plans to go to the moon it becomes important to know how safe astronauts will be against all environmental factors and whether special interventions are needed. Lunar dust is a concern since the Apollo astronauts noticed that dust was detrimental to their productivity. The dust affected many things ranging from damaging airtight seals on gloves to anecdotal adverse health effects. Gene Cernan of Apollo 17 said, "*I think dust is probably one of our greatest inhibitors to a nominal operation on the Moon. I think we can overcome other physiological or physical or mechanical problems except dust*". This problem must be addressed before returning to the moon. Our project is focused on the health impacts of the astronauts when exposed to the lunar dust rather than mechanical failures. Reports of Apollo astronauts having symptoms of

hay fever and smelling gun powder has given NASA a reason to be concerned about the affect of lunar dust on the pulmonary system.

The organization that I am part of is in the Habitability and Environmental Factors Division which is interested in looking at different stimuli the astronauts will be exposed to, such as radiation, microgravity, and other environmental factors. Space Toxicology is one section of this division. My project falls under space toxicology and trying to determine the safety of astronauts while on the Moon and Mars. I have been able to show that lunar simulant and lunar dust forms more reactive oxygen species than quartz. I have also been able to show the relative cytotoxicity of ground and unground dust and quartz on A549 cells. These tests are very important in determining the potential toxic effects of lunar dust on astronauts as they return to the moon.

Impact of the MUST Internship on My Career Goals

This internship has been an amazing opportunity for me. It allowed me to work in a lab and determine whether it was a career path I wanted to go down for the rest of my life. It also gave me a great look at NASA and the work they do day to day. After this summer I have become caught up in the fervor of NASA. I learned about space medicine and have become greatly interested in it. I have grown so interested in it that I have started contemplating going to medical school to get an MD/PhD and specialize in space/flight medicine.

One of the most interesting aspects of working in a Space Life Science Division is the Space Life Science Summer Institute (SLSSI). This program gave numerous lectures

from scientists, astronauts, and division chiefs. These lectures allowed summer students to be able to view other research being done in space life science. Through this program I learned things that were very interesting and stuff that I had no idea NASA even did. The SLSSI allowed me to see that NASA is a great place to do research and made me feel confident about coming back and working on a fun new project next summer.

Another part of my internship that showed me that NASA would be a fun environment to work in was the people. The most important was my mentor William Wallace. Dr. Wallace not only introduced me to NASA research but also encouraged me to try new procedures and experiments to expand the knowledge of dust research. With his encouragement I have grown more confident in my abilities as a scientist and my ability to find ways to answer new questions. I also had a wide range of guidance from other employees in the lab. They taught me how to use new equipment and walked me through procedures so I would get the hang of it and be able to do it on my own. The people I worked with and interacted with made my internship a great experience, and the other interns here were great people to spend time with and get to know. I am glad that I was able to receive this experience and it is a summer I will never forget.