HEALTH EFFECTS OF LUNAR DUST: A GATHERING PLACE FOR SCIENTIFIC DIVERSITY. J. T. James[1] and R. L. Kerschmann[2], [1]NASA Johnson Space Center, 2101 NASA Parkway, Mail Stop SF23, Houston, TX. 77058, john.t.james@nasa.gov, [2]NASA Ames Research Center. Space Biosciences Division, Moffett Field, CA 94035, russell.l.kerschmann@nasa.gov

Introduction: The purpose of our presentation is to stimulate thought on the properties of lunar dusts that matter to biologists concerned with health effects. The Lunar Airborne Dust Toxicity Advisory Group (LADTAG) was formed by NASA in the fall of 2005 following a spring meeting at Ames Research Center in which the issue of health effects of lunar dust was reviewed. The findings from that meeting were noteworthy in that scientists who seldom share data were charged to determine the health risk associated with exposure to lunar dust. These scientists consisted primarily of lunar geologists and medical specialists.

The conclusions from that meeting were that no one has ever done a credible study of the toxicity of authentic lunar dust, although credible studies of lunar dust simulants had been published. Suggestive evidence from earth-analogues of mineral dusts suggested that lunar dusts would not be especially toxic unless they had reactive surfaces. Existing repositories of lunar dust have probably lost their original surface reactivity. The environmental conditions that produce reactive sites on lunar dust are diverse and may consist of solar radiation fluxes, micro-meteroid impacts, and plasma charging at the terminator. Geologists had not paid much attention to the <10 micron fraction of lunar dust, and the mechanisms of surface activation were not well understood. It was clear that lunar dust had a large surface area and a high iron content, both properties that could cause the dust to be uncommonly toxic. Finally, it was unclear what differences in dusts from different regions of the moon might cause marked differences in health effects. How different were dusts from the highland and mare regions? How different were dusts from the poles compared to dust from equatorial areas, and how does the maturity of the dusts affect their biological properties?

Review of the Apollo experiences suggested that for some individuals exposure to lunar dust could elicit respiratory irritation and perhaps an allergic-like response. Apollo astronauts typically donned helments if the airborne dust began to irritate their eyes. We came to understand that in addition to the respiratory health effects we needed to consider the mechanical properties of larger dusts that could enter the eyes or abrade the skin under some conditions.

Our Plan: The LADTAG Research Working Group (RWG) has conducted preliminary experiments and has developed a research plan involving a diverse group of scientists to definitively set airborne standards to protect crew health and to define health risks to the eyes and skin. For respiratory effects we are concerned with particles smaller than 10 microns, and especially those particles that might be in the nano-size range (<0.1 microns). For abrasive effects to the skin and eyes, our concern is focused on larger particles that have the potential to mechanically (and perhaps chemically) injure surfaces.

Our approach to characterizartion of the pulmonary effects consists of 4 aspects. These include chemical experiments to characterize dust surface activation and its persistence in a habitable environment, cellular experiments to assess the ability of selected types of cells to deal with activated and passivated dusts, whole animal experiments in which fluid containing test dusts is instilled into the lungs of laboratory animals, and nose-only inhalation studies in which the test dust is inhaled by laboratory animals constrained so that they must breathe the dust. Given this armada of biological experiments, we must be confident that we understand the geological properties of lunar dust to the extent possible.

To assess the health risks to skin and eyes several test systems have been devised. One approach to assess the abrasiveness to skin is to mechanically rub the dust on the surface of porcine skin while measuring the resistance across the skin. For ocular toxicity effects ordinary testing in rabbit eyes by standardized techniques will be used, but more sophisticated systems may be needed to understand mechanisms.

Geological Science Gaps: While the LADTAG consists of experienced lunar geologists, it is to our advantage as biologists to ask our questions to the broadest possible audience. With that in mind, the following geological science gaps are of interest as we select simulants and authentic dust to test:

-Can we assume that existing samples of authentic lunar regolith and dust have lost surface reactivity?

-What size-distribution profile would one expect in the first few centimeters of lunar dust deposited on the moon's surface in a highland region of the south pole?

-How will highland dust be different with latitude (pole vs. equatorial)?

-How mature or immature will dust be at the south pole highlands?

-What properties of the lunar environment cause surface activation of the dust and what is the nature of that activation?

-How does one simulate the lunar environment on earth?

-How long will surface activation persist in a habitable environment (water vapor and oxygen)?

-Are there special types of dust that we need to be aware of?

-What is the settling time of lunar dust in a habitable environment?

-How important is the deposition of vapor on the surfaces of dust during micro-meteroid impacts?

-What have we forgotten?

Conclusion: As biomedical specialists (toxicologist and pathologist) we have set out to characterize the health effects of lunar dusts. Since these dusts are formed in, and have existed in, an exotic environment for millions of years, we must be careful with any deductions from earth-based analogs. In particular, we must thoroughly understand the geological properties of lunar dusts that could affect health. This requires us to listen well to those scientists who have insight into the full range of lunar dust properties.