HUMAN SAMPLE RETURN ACTIVITIES ON THE MOON. A SCIENCE, EXPLORATION, AND TECHNOLOGY VIEW FROM THE APOLLO PROGRAM TO THE FUTURE. C.K. Shearer[1], [1]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131 (cshearer@unm.edu).

Introduction: The exploration of the Moon that climaxed with the Apollo Program resulted in a paradigm shift not only our understanding of the Moon, but in our scientific perspective of fundamental processes at work in the Solar System and our own place in it. Critical to these immense intellectual steps forward was the collection of lunar samples. As we look forward to a new period of human lunar exploration, the importance of samples looms even larger. This importance is tied to three concepts: (1) the Apollo Program explored and sampled a relatively small area of the Moon and therefore our understanding of the Earth-Moon system as it stands is incomplete, (2) samples and their analysis in terrestrial labs provide a unique prospective unavailable by other exploration tools, and (3) the symbiotic relationship among sample-surface-orbital observations is invaluable for the exploration of the Moon and feeds forward to the exploration of the Solar System. Here, we examine some of the important science and exploration questions that may benefit from additional human exploration and sample collection and examine the sample documentation-acquisition-preservation-curation advances since the Apollo Program that may be used to answer these questions.

Exploring the Solar System through sample return from the Moon: Numerous scientific problems that link the origin and evolution of terrestrial planets can be addressed through a series of missions that target the return of samples from numerous lunar destinations.

Bulk Composition of the Planets: Test models of Solar System nebula and planetary accretion. What is the role of giant impacts in the final composition of the terrestrial planets?

Primary Differentiation: Test models for planetary differentiation and establish timing of initial differentiation. Did all the terrestrial planets differentiate through a common process (Magma Ocean)? Was initial differentiation rapid or protracted?

Origin and Distribution of Volatile Reservoirs: Test models for the delivery and storage of volatiles to the Moon. How were water and other volatiles delivered to (and lost?) and stored in the terrestrial planets? What are the distribution, nature, and mass of volatile reservoirs on the Moon?

Bombardment History: Test the Cataclysm Hypothesis and thereby constrain the process(es) that led to the early heavy bombardment. Do the inner planets share an early bombardment history? What is the response of early planetary crusts and mantles to the early bombardment? What is the role of the bombardment history of the inner Solar System in the evolution of environments for early life and extinctions on Earth?

Magmatic and Thermal History: Test models for the magmatic and thermal evolution of terrestrial planets. What are the structures, compositions, and dynamical histories of planetary crusts and mantles?

Surface Processes: Test models for the evolution of planetary surfaces. How do planetary surfaces interact with exosphere/atmosphere?

Examples of Specific Sample Measurements: (1) Determine compositions precisely to infer bulk planet composition and to test models planetary accretion. (2) Determine ages and isotopic composition of basalts and highland lithologies to reconstruct magmatic history, composition of the mantle, and timing and style of primary differentiation. (3) Determine the volatile composition of basalts to understand planetary volatile reservoirs. (4) Detailed microanalysis of regolith to understand solar wind-regolith and exosphere-regolith interactions. (5) Determine the ages of large impact basins. (6) Determine the isotopic and chemical analysis of surface volatile reservoirs.

Technology Investment and Capabilities: The Apollo Program was extremely innovative in sample acquisition tools, sample containment, and sample curation. These tools and protocols evolved during the short-lived Apollo program. The acquisition tools had a wide range of applications and included simple rock hammers, scoops, rakes, drills and contact soil sampling devices. Sample return containers included "simple" rock box to gas analysis and special environmental sample containers. There are numerous examples for aiding and improving surface sample acquisition activities aimed at supporting the above science goals. For example: (1) handheld, contact analytical instruments (e.g. XRD/XRF) may assist astronauts in sample selection and thereby reduce sample return mass without compromising science and exploration goals through high-grading samples. These tools must provide easy to interpret data quickly and safely to aid the decision making process and can be linked to a science backroom during the mission. (2) The various types of special sample containers used during Apollo worked with varying degrees of success on the lunar surface. Reexamining these successes and failures will aid in the design of easy to use containers that should be used for preserving the lunar volatile record in samples.